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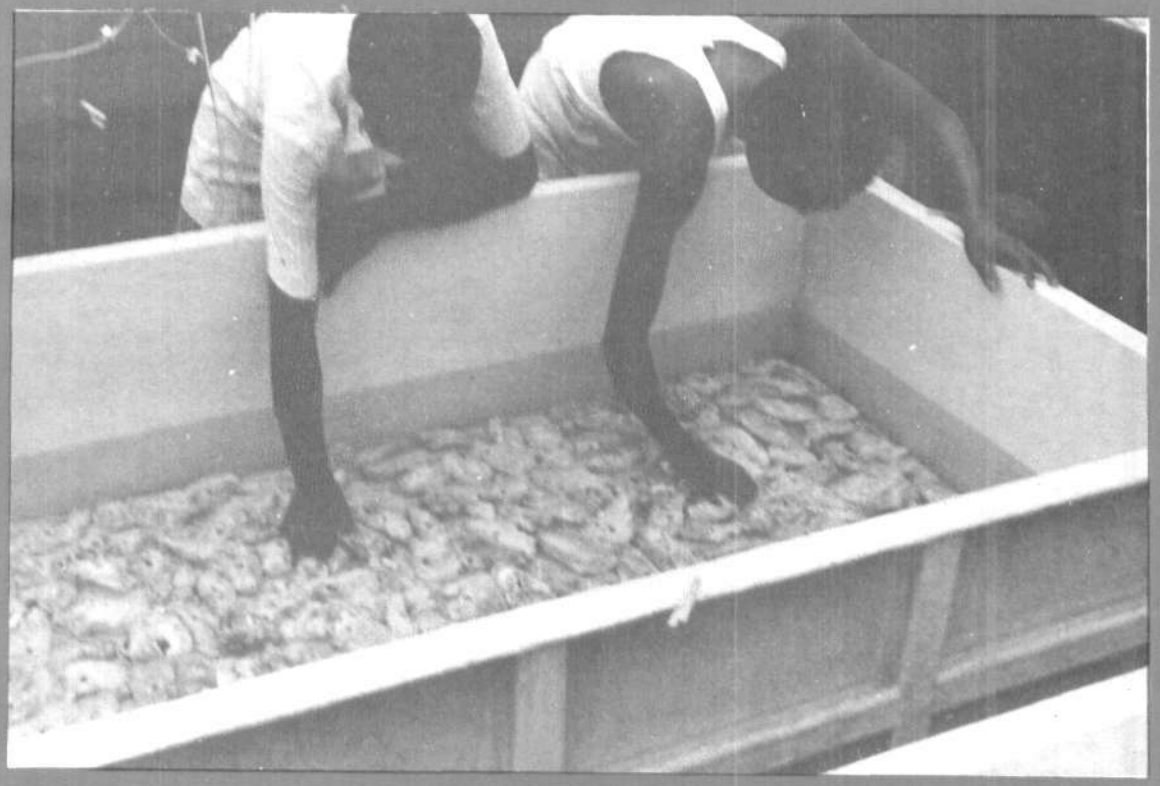

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH

समुद्री मात्स्यिकी सूचना सेवा: समुद्री मात्स्यिकी पर आधारित अनुसंधान परिणामों को आयोजकों, मत्स्य उद्योगों और मत्स्य पालकों के बीच प्रसार करना और तकनोलजी का प्रयोगशाला से क्षमशाला तक हस्तांतरित करना इस तकनीकी और विस्तार अंकावली का लक्ष्य है।

THE MARINE FISHERIES INFORMATION SERVICE : Technical and Extension Series envisages dissemination of information on marine fishery resources based on research results to the planners, industry and fish farmers and transfer of technology from laboratory to field.

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Front cover photo : Cultch material (empy edible oyster shells) is being laid in the larval nearing tank for the settlement of the edible oyster spat in the hatchery at Tuticorin Research Centre of CMFRI

Back cover photo : Mollusean shells brought by trawlers from the trawling grounds off Quilon heaped at the Neendakara Fisheries Harbour. These are used in cement industry

PROSPECTS FOR DEVELOPMENT OF OYSTER CULTURE IN INDIA

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Introduction

Oyster culture has long history dating back to the first century B. C. when the Romans have practised it. In 1988 oyster production by aquaculture was 10 lakh tonnes, mostly coming from temperate countries. In the same year Korea produced 2.86 lakh tonnes, followed by Japan 2.71 lakh tonnes, U. S. A. 1.37 lakh tonnes and France 1.33 lakh tonnes. In 1989 about 20,000 tonnes of oysters valued at US $ 67 million found place in global exports. At present oysters account for 36% of the world aquaculture production of molluscs from the sea.

Oysters occur all along the Indian coasts in backwaters, bays and estuaries forming subsistence fisheries. The meat is consumed locally and of late there is growing demand for it in some parts of the country. The shell is used in lime based industries. At present oyster culture is not practised in the country except for the experimental culture conducted by the CMFRI.

Oyster resources

Six species of oysters namely *Crassostrea madrasensis* (Preston), *C. rivularis* (Gould), *C. gryphoides* (Schlotheim), *Saccostrea cucullata* (Born), *Saxostrea cucullata* (Awati and Rai) and *Hyastissa hyotis* (Linnaeus) occur in Indian waters. The first four species are of commercial value. The oyster beds are distributed in several centres along the Indian coast and production from these beds is not monitored on regular basis. However, the surveys conducted by the CMFRI at some of the important production centres indicate the landings at less than 2000 t/whole weight/year.

In Orissa, beds of *C. madrasensis* are located in Bahuda estuary near Sonapur and at the mouth of the Chilka lake. In Andhra Pradesh, oyster beds are distributed in Sarada estuary near Visakhapatnam, Bhimunipatnam backwater, the banks of Upputeru canal (Kakinada), Gokulapalli backwaters and Krishnapatnam. In Gokulapalli, oysters are regularly exploited. Of all the maritime states, Tamil Nadu has rich oyster resources. Near Madras, in Pulicat backwaters oyster beds cover about 10 ha and standing stock of oysters has been estimated at 1320 t. Ennore backwaters have 45 ha oyster beds with standing stock of 18,600 t and oysters are regularly exploited by the fisherfolk.. There are oyster beds of 1.6 ha in Vaigai estuary near Athankarai with biomass of 389 t. At Tuticorin three oyster beds extending in an area of 3.25 ha sustain considerable oyster population. Oyster beds exist in Killai backwaters, Pazhayar estuary, Muthupet swamps and Thambraparani estuary. *C. madrasensis* occurs in Andaman Islands at Port Blair, Havelock island, Mayabunder and Dighipur. In Kerala the oyster populations are small and their growth and condition have been reported to be poor in the Ashtamudi and Vembanad lakes and Cochin backwaters. In north Kerala in the estuaries of Mahe, the creeks of Dharmadam, Valapattanam, Neeleshwar and Chandragiri oysters are known to occur and there is regular exploitation. In Karnataka, oyster resources are distributed in Nethravathi, Mulki, Udavara, Venkatpur, Coondapoor and Kali estuaries and oysters are regularly exploited.

C. gryphoides occurs along the west coast of India, particularly in northern Karnataka, Goa, Maharashtra and Gujarat. In Maharashtra this species is found in several creeks and backwaters and is regularly exploited. At several places along the Gulf of Kutch this species occurs and the population density is low.

C. rivularis is found in the coastal waters and creeks of Gujarat where the oysters are exploited for the shells. This species is known to occur along with *C. gryphoides* in Mahim, Ratnagiri and Jaytapur in Maharashtra.

Saccostrea cucullata is found on rocky substrata in marine environment in shallow coastal and intertidal areas. It occurs all along mainland coast of India and Andaman and Lakshadweep islands.

Oyster culture

The Indian edible oyster *C. madrasensis* is a highly suitable candidate species for culture. It grows fast, attains large size and tolerates wide salinity variations. The CMFRI has given thrust to researches on oyster culture for the last 15 years, culminating in the development of a complete package of oyster culture technology, including hatchery production of seed of this species.

Seed collection from nature : After ascertaining the ripeness of gonads of oysters and the appearance of oyster larvae in the plankton, spat collectors such as lime-coated tiles, oyster shells etc. are laid in the sea. The oyster larvae settle on these collectors as spat and are reared for 2-3 months in net bags.

Seed collected from the natural grounds accounts for major share of oyster production by farming.

Seed production in the hatchery : The CMFRI has succeeded in developing the hatchery technology for oyster seed production in 1982. Since then the techniques have been standardised for mass production of oyster seed. In the hatchery, the operations involve selection and holding of brood stock, induced spawning by thermal stimulation, larval rearing, preparation of spat collectors, spat rearing and culture of algal food. In about 3 weeks the larvae settle as spat, with a survival of about 10%. The spat are hardy and as they grow, the mortality rate is much reduced.

On-bottom culture : As the name suggests, the oyster seed are grown directly on the sea bed, either intertidally or subtidally. In either case the substratum should be reasonably firm. The oyster seed, attached to the spat collectors, are planted on the bottom and in one year they grow to the marketable size of about 86 mm. This method is low-intensive, both for capital and labour. It is practised extensively in the U.S.A. and production is about 5 t/ha/year. In India on-bottom farming of oysters is yet to be experimented.

Off-bottom culture : There are several methods and the advantages are relatively rapid growth and good meat yield, higher production in unit area and less vulnerability to attacks by benthic predators like crabs and starfishes. However, the methods are capital and labour intensive when compared to on-bottom culture.

In the rack and string method, shell strings with oyster spat attached to shells are suspended from racks in shallow waters. Production is estimated at 80 t/ha/year.

In the rack and tray method, cultch free seed oysters are stocked in box type cages and suspended from racks. The annual production per hactare is estimated at 120 t. Though production is high, this method requires large capital investment.

In the stake method, oyster shells with spat attached to them are nailed to wooden poles and these poles are driven into the substratum. Production by this method is estimated at 22 t/ha/year.

All these methods can be adopted in shallow waters, below 3 m depth. In deeper waters rafts are used for floatation.

In recent times, particularly in Japan and Korea, there is a shift to longline method of oyster culture. The oyster seed is either directly fixed on a rope or shell strings containing oyster seed are suspended from a rope. The rope is held in position by a series of floating barrels. This method is followed in deeper waters. Longlines withstand rough sea conditions better than rafts. This method is yet to be experimented in our country.

Where oyster meat is consumed fresh with one shell valve removed, the shape of the shell is important for serving on the table. Cultch-free oyster spat grown by rack and tray method generally attain uniform shape to meet this requirement.

Suggestions for development of oyster culture

For the development of oyster culture in the country well co-ordinated and concerted efforts are required in several directions.

It is necessary to conduct a survey of oyster resources and areas suitable for oyster farming along the Indian coast. The CMFRI has initiated a programme on these aspects and data have been collected for the entire Tamil Nadu coast and parts of Kerala and Andhra Pradesh. A comprehensive picture about oyster resources and sites suitable for oyster farming is necessary for all maritime states.

After identification of sites for oyster culture, a programme on a small scale, for location testing may be taken up before embarking on a large scale project. A study of this type helps to assess whether the oysters are interacting favourably with the environment resulting in good growth and production.

While considerable information, relevent to culture, is available on *C. madrasensis*, little is known about *C. gryphoides* which is dominant along the Maharashtra and Gujarat coasts. The suitability of this species for culture is to be studied, particularly in these two states. Gujarat State Fisheries Department has successfully transported *C. madrasensis* seed from Tuticorin hatchery to Sikka and made attempts to study the suitability of this species for culture in Gujarat waters. The reports indicate that growth is slow at 30 mm/year. However, further work is required in this direction.

The coastal areas suitable for oyster culture should be made available to prospective oyster farmers on lease basis and suitable legislation is to be enacted for this purpose after taking into consideration, activities such as traditional fishing.

Concurrent with the development of oyster culture, monitoring of the water quality of the oyster growing areas is to be undertaken. The coastal waters are prone to bacterial, heavy metal and pesticide pollution which adversely affect the quality of the oyster meat. Also depuration facilities are to be developed at important production centres.

Prospective entrepreneurs require lots of information on the economics of different types of oyster culture and the cost of seed production in the hatchery. The data generated in the operation of a Research project by the CMFRI are used in working some of these aspects and the results are indicative of the potential. Operation of semi-commercial scale projects is the need of the hour to evaluate the economics. A beginning is made in this direction by the collaborative project on edible oyster culture between NABARD and CMFRI, being operated at Tuticorin.

Product development is an important area requiring thrust. Both low cost and value added items are to be developed from oyster meat to cater to the requirements of different categories of consumers. Market research and extension are necessary to popularise these products. Also overseas markets are to be explored for the export of oyster products. Export of live oysters is promising and needs careful evaluation.

Several inputs are required for oyster farming. Financial institutions can play a crucial role in extending credit facilities at concessional rates to the entrepreneurs venturing into oyster culture.

There is lack of awareness among the prospective entrepreneurs about the benefits that would accrue by taking up oyster farming. Demonstration of oyster culture and publication of relevent material in popular style help to overcome this problem and the CMFRI is acting on these lines.

EXPERIENCE PAPER ON THE OPERATION OF PILOT PROJECT ON OYSTER CULTURE AT TUTICORIN

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Introduction

The technology of oyster culture was developed in India at the Central Marine Fisheries Research Institute. An experimental farm was established at Tuticorin bay in an area of 0.25 hectares. Different growout methods have been tried and it has been assessed that the shell string method could be practised with relatively low cost inputs with a production rate comparable to highly efficient systems such as rack and tray method or raft culture. The expected production by the ren-culture or shell string method is 80 tonnes/hectare/year. The Institute could not so far take up any programme on large scale production of oysters to establish the

economic viability of the technology. At this juncture, the National Bank for Agriculture and Rural Development, offered partial assistance from its Research and Development fund to operate a pilot project on oyster culture in one hectare for three years at Tuticorin and the project has been in operation since 1991.

Objectives of the project

The objectives of the pilot project include field testing of the oyster culture technology on a pilot scale, to modify the techniques where required, to generate adequate economic data on oyster farming and to create awareness among the concerned about the benefits of oyster culture. Successful implementation of this project would lead to the establishment of oyster culture on commercial lines in the country, generate income and employment in coastal rural areas and increased oyster production would help to improve the supply of animal protein in the diet of the people. There is also scope to export oyster products and earn foreign exchange.

Operation of the project

The project was initiated during February 1991 and the preparatory phase of the project extended for over 8 months. During this phase major efforts were put towards the production of seed required for the culture system, procurement of stores and arrangement of various facilities required in the scaling up of production of spat, arrangement of contract labour, organising systems for nursery and farming.

The important parameters or systems under study in the process of oyster culture are : seed production, nursery rearing, replanting in grow-out system, growing to marketable stage, harvesting, post harvest handling, processing and marketing.

The associated subsystems in oyster culture are : environment monitoring, control of predators and competitors, monitoring of growth and condition of oysters, management of materials and infrastructure facilities and management of labour force and training.

The final part of the programme is the evaluation of the results.

Seed production

This is accomplished in six operational phases namely : selection, holding and conditioning of brood stock, induced spawning, larval rearing, preparation of cultch materials, production of spat and culture of microalgae as food for larvae, spat and brood stock. These six functions, though there may be some variation in how they are accomplished, are common to both research and commercial operations. In our effort to scale up the operations, the existing facilities of some of the units viz. larval rearing, cultch preparation, larval setting and algal production are increased. The basic facilities such as filtered water and air supply system were toned up.

With sediment free and continuous supply of filtered seawater, uncontaminated and uninterrupted supply of microalgal feed, the growth and survival of larvae are increased. The larvae are reared in the semistatic water medium in which 50% of the water is exchanged every day and thrice in a week the rearing tanks are cleaned, filled with filtered seawater and restocked with the larvae. The tanks are continuously aerated and feed is provided every day. The larval density of the tank is assessed twice in a week and based on the density and size of the larvae the feed is regulated.

The factors that affect the survival and growth of the larvae are the quality and quantity of the algal food, the ecological parameters, such as salinity, 0_2 content, pH and temperature. The stress caused by metabolites and organic waste in the tanks is reduced by daily exchange of water before feeding.

In the preparation of cultch material for spat collection, a hole is drilled in the centre of the oyster shells (valves), soaked in water and cleaned with brush to remove the dirt and extraneous matter, rinsed in water and immersed in chlorinated (5 ppm) filtered seawater for 2 to 3 hours. The sterilized shells are further immersed in filtered seawater for 2 to 3 days in order to ensure that the pH of water in the hatchery tanks is maintained close to normal value. These shells are then laid on the bottom of the tank for settlement of spat.

When 70 to 80% of the larvae reach the 'eyed stage', they are transferred to the setting tanks. In two to three days they set on the shells especially on the concave side. The settlement is completed within 2 to 5 days. In each tank 500 shells are arranged on the bottom and about

50,000 eyed larvae are released. The optimum rate of settlement is 50 to 70% and on each shell around 70 to 80 spat may set. The factors affecting the settlement are pH, salinity, 0_2 content and water movement. Water exchange is carried out daily without disturbing the shells. The tanks are well aerated and the water is agitated to prevent uneven settlement in the tank.

Nursery rearing and replanting in grow-out system

The shells with spat set on them are arranged in 5 mm thick nylon rope with proper spacing. In a 1.5 metre long rope, 6 shells are arranged and suspended in the tanks filled with raw seawater, for further growth. After 15 days the strings are transferred to nursery area and suspended from racks in velon screen pouches. Three to four shell strings are held in each pouch. After 30 days of nursery rearing the velon screen pouches are removed and the strings are suspended from the racks in the farm with a space of 30 cm between adjacent strings. From a rack measuring 25 m in length 80 strings are suspended. The damage caused to the racks by wind and wave action are attended to and the fallen strings are retrieved and suspended again from the racks.

Growing to marketable size

In the farm, stocking of seed oysters have been carried out in 0.76 ha by constructing 96 racks. Each rack occupies an area of 80 m^2 and 80 strings are suspended from a rack. The growth of oysters have been assessed by periodical recording of the weight of the strings and the mortality by fallout of the oysters from the strings. The details of weight and number of spat/oysters per string from the time of transferring from the hatchery to the time of harvest (12 months) have been furnished in Table 1.

On an average the oyster attains 15.2 g per month and the mortality or fallout of oysters is estimated at 3.9% per month. The survival rate at the end of one year is 52.7%. At the time of harvest the oysters weigh 165 to 181 g per piece with an average of 175.0 g.

Harvesting and post harvest handling

Oysters could be harvested at the end of tenth month if the condition of the meat is at optimum level. The condition factor of the oyster

TABLE 1. *Average growth of oysters in strings by weight and percentage survival for 12 months period in oyster farm*

Period of rearing in months	Average weight (kg) of one string with spat/ oyster	Average Nos. of spat/ oyster/ string	Average weight of an oyster in g	Percentage of survival
1	0.525	74.0	—	—
2	0.980	65.0	7.00	87.8
3	1.755	61.0	20.16	82.4
4	2.585	58.4	35.50	78.3
5	3.350	56.0	50.40	75.6
6	4.295	53.5	70.10	72.2
7	4.800	51.0	83.80	68.9
8	5.250	49.0	96.40	66.2
9	5.800	47.0	112.20	63.5
10	6.240	45.0	127.00	60.8
11	6.920	43.0	148.00	58.1
12	7.350	39.0	175.00	52.7

which indicates the fullness of meat in the shell cavity is an important factor to be considered before harvesting. The increase in size of the gonad is associated with the optimum condition of meat in the shell and the condition value between 120 and 150 is considered to be good for harvesting the oysters. The condition factor is generally estimated by using the formula :

$$\frac{\text{Weight of dry meat} \times 1000}{\text{Volume of the shell cavity}}$$

Although a seasonal pattern has been observed in the values of condition index of the oyster population of the area, diurnal variation of temperature show a well defined relation with the changes in the stages of gonad. The mean value of condition factor of oysters was found to be at optimum level when there is a pronounced diurnal variation in water temperature. This feature has been observed during March-April and August-September.

During harvest the strings are untied from the racks and transported to the shore. The strings are then suspended in cleaning or depuration tanks. After initial cleaning of the oysters by using a strong jet of water, the oysters are depurated in running filtered seawater for 12 hours. With the existing facilities at Tuticorin, on an average, 1.5 tonnes of oysters could be

depurated at a time. The depuration process has been carried out from 6 pm to 6 am and rest of the post-harvest activities such as heat-treatment of the oyster, shucking of the meat, processing and preservation of oyster meat have been carried out during the day time. On an average 115 kg of oyster meat has been shucked, processed and preserved per day.

Since July '92, around 3655 numbers of shell strings have been harvested on four occasions, yielding 27.95 m tonnes of shell-on oysters.

Marketing

Oysters are marketed in live condition; oyster meat is marketed fresh, frozen and in canned condition.

Experiments indicate that live oysters packed in wet gunny bags can safely be transported for 25-30 hours without mortality and in good condition. Small holding tanks having filtered seawater or artificial seawater and provided with adequate aeration, would keep the oysters alive for a few days at the whole-saler's premises. During the present study live oysters have been transported from Tuticorin to Cochin and Madras.

There is regular local demand for fresh oyster meat in Tuticorin. Frozen (block) oyster meat is supplied in bulk quantity to the Integrated Fisheries Project (IFP), Cochin. The IFP has developed and standardised the canning techniques for various types of oyster products. 'Oysters in brine', 'smoked oysters in oil' and 'oyster curry' are some of the value added products marketed directly to consumers in various regions of the country through the State Fisheries Development Corporation, Cooperative Department Store, Super Bazzar and other outlets on preferential basis in order to make the products available at reasonable prices. The whole of northeastern India seasonally responds well to these products. At present there is large demand for canned oyster products in the northeastern states viz. Mizoram, Nagaland, Assam etc.

Oyster shells, the co-product, account for about 85 to 90% of the total weight of live oysters and contain 52-55% of calcium oxide by weight. The shells are used in the manufacture of calcium carbide, lime, fertilizers, cement and in other lime-based chemical industries. Locally there is very good demand for oyster shells. Investigations on the following subsystems associated with the operation of the project, have been carried out.

Environmental monitoring

The temperature salinity, pH, primary production and turbidity of the water in the oyster farm have been investigated. The dissolved oxygen ranged from 2.69 to 9.13 ml/l. The 0_2 content remained high during October and low during January. Inversely, the gross primary productivity was observed to be low during October and high during January. The turbidity varied from 0.77 to 12.3 NTG. High values of turbidity were observed during August and September and low values during April & May. The pH value remained uniform at above 8.0 with an average of 8.26 except during November and December when it was around 7.92. Water temperature was high during October and low during November. The changes in values of the various parameters were mainly due to the southwest and northeast monsoons. During the course of the investigations, extreme changes in the values of environmental parameters, which adversely effect the oyster population were not observed. Fouling organisms such as *Balanus*, *Modiolus* and tubiculous polychaetes are known to settle over oysters. Fouling was found to be high during April and May when turbidity in the water was low. During the rest of the period fouling was moderate.

Control of predators and competitors

Crabs of the genus *Charybdis* and oyster drills (*Cymatium*) are common predators of this area. Predation has been found to be size specific and young oysters are more vulnerable than grown up oysters. Hence young oysters (spat) are enclosed in velon screen pouches and reared till the shell valves become thick enough to withstand the attack of predators. Oyster drills occur commonly in tray culture system, but found very rarely in the ren method of culture.

The suspension of shell strings from the racks are so arranged that the oysters are exposed at least two to three hours during low tide. This helps in reducing the intensity of settlement of foulers, especially barnacles and polychaetes.

Monitoring of growth and condition factor

The growth of oysters is expressed in terms

of increment in weight and shell length. Unlike the oysters grown by rack and tray method or bottom culture, in shell string culture the growth shoots are found all over the edges of the shells and the oysters are roundish or ovate in shape. In rack and tray method the growth rate, in terms of increment of weight has been estimated as 10.5 g/ month and at the end of one year the oysters attain an average weight of 126 g. The oysters raised through shell string method register a growth of 15.2 g by weight/month and at the end of one year attain 175 g. In this method of culture, oysters could be harvested at the end of 10 months.

The percentage of meat weight in the weight of whole oyster varies from 4.5 to 12, with an average value of 9.2. The values of condition index exhibit variation in respect of time, sex and stages of development of gonad. In the farm it ranges from 70.8 to 180.6 with a mean value of 85.7.

Management of materials and infrastructure facilities

The infrastructure facilities required for the project have been partially acquired. One fibre glass dinghy, motor, pump set, and a deep freezer have been procured. Arrangements have been made to carry out the works connected with construction of nursery pond.

Expenditure towards the procurement of farms materials, farm labour, fuel charges, other contigencies and office contingencies have been spent to the extent to which the works have been carried out. 96 racks (each 25 m in length) in the farm and 25 racks (each 10 m in length) in the nursery area have been constructed. Around 600 number of 18 m long eucalyptus poles have been utilised for the construction of these racks. Nylon rope of 5 mm thickness for stringing the spat collectors (shells), coir rope for lacing the poles, velon screen pouches as nursery bags have been procured in bulk quantities for the farm work.

Accessory farm tools such as sickles, hammers, drillers, scrappers, hand gloves and canvas shoes have been procured to facilitate the farm labours to carryout the construction of racks and maintenance of the farm.

Management of labour force and training

Labour force required for the conventional industrial and agricultural sectors can be easily organised. However, mariculture being a new avocation, in this area, the labour required are not readily available. Hence unskilled, semi skilled work force have been trained and the various manual inputs required for the operation of the project have been clearly identified and classified.

On reviewing the progress of work of the project, it has become clear that although the expected target could not be achieved in stipulated time, the results are very much encouraging in respect to the production rate of oysters. The main constraint is that the Institute's experimental hatchery is not able to supply the required quantity of oyster seed in stipulated time. While scaling up the production of oyster seed in the hatchery, we faced problems such as inadequate supply of filtered seawater and algal feed. However, we have not faced any problems related to the field culture of oysters.

Further work is under progress. The final evaluation of the work of this project will be taken up on the completion of the project.

RESEARCH AND DEVELOPMENT WORK CARRIED OUT ON EDIBLE OYSTERS IN GUJARAT

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Introduction

Gujarat has more than 1600 km of coastline and although the edible oysters occur all along the coast, they are mainly concentrated in the Gulf of Kutch. The Molluscan Research Station was established in 1977 at Sikka near Jamnagar and since then the work on edible oyster, pearl oyster, windowpane oyster etc. received considerable attention.

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Regular exploitation of both live oyster and oyster shell was in vogue in certain areas of the Gulf of Kutch. The cement industry at Sikka obtained longterm lease for lifting the sand for the production of cement. While lifting the sand, the industry also removes live oysters and oyster shell. This practice has led to drastic decline in the oyster population. With a view to assess the edible oyster populations, surveys were conducted along the Gujarat coast, and the results together with information on the transport of oyster spat and experimental culture of the oyster, are given in this paper.

Edible oyster resources survey

Oyster resources survey was conducted by the transect method from Jakhau in the Gulf of Kutch to Umargaon in south Gujarat. *Crassostrea gryphoides* was dominant followed by *Saccostrea cucullata* and *C. rivularis*. However, the density of oyster population was very low with about one oyster/m^2 at all the places surveyed except at Sikka where a small oyster bed of 0.05 ha had a density of 142 oysters/m^2 (Table 1-3). The study shows that the natural populations of the oysters along the Gujarat coast occur in very low

TABLE 1. *Results of edible oyster survey along the Gujarat coast during 1988-'89*

Sl. No.	Location	Extent of area surveyed (ha)	Edible oyster species	Type of substratum	Estimated oyster population in numbers
1	Jodiya	6.90	*C. gryphoides*	Muddy, sandy & scattered stones	150
2	Balachadi G-1	100.00	*C. gryphoides*	Rocky & muddy	60
	,, G-2	150.00	,, ,,	,, ,,	60
	,, G-3	300.00	,, ,,	,, ,,	67
3	Namathi creek	0.47	,, ,,	Muddy & scattered stones	1,100
4	Shirval	900.00	,, ,,	Sandy, rocky and muddy	14
5	Sarmat Marudi creek	140.00	,, ,,	Rocky & muddy	700
6	Sikka	0.05	*S. cuculata*	,, ,,	66,456
7	Gagawa	1.17	*C. gryphoides* *C. rivularis*	Rocky, muddy & sandy	200
8	Singach	1.89	*C. gryphoides*	,, ,,	100
9	Salaya (Khanara creek)	1.20	,, ,,	Rocky & sandy	50
10	Poshitra Lakhu point	0.40	,, ,,	,, ,,	40
11	Arambhada	0.50	,, ,,	Muddy & scattered stones	80
12	Dwarka (Gomti Ghat)	0.39	*C. gryphoides*	Muddy & scattered stones	100
13	Harshad Medha creek	41.55	,, ,,	Rocky & muddy	90,000
14	Navibandar	22.50	,, ,,	,,	75,000
15	Meghal	50.00	,, ,,	Muddy & scattered stones	2,000
16	Velan — Madhavad	0.02	,, ,,	,,	30
17	Samadhiyani (Victor Khadi)	3.50	,, ,,	,,	3,500
18	Datardi	1.00	,, ,,	,,	6,000

TABLE 2. *Results of edible oyster survey along the Gujarat coast during 1989-'90*

Sl. No.	Location	Extent of area surveyed (ha)	Edible oyster species	Type of substratum	Estimated oyster population in numbers
1	Modhava	5.0	C. *gryphoides*	Rocky & muddy	1,500
2	Zarpara	0.9	,, ,,	,,	1800
3	Dndeli	100.0	,, ,,	,,	14
4	Aghore	2.5	,, ,,	,,	10
5	Halai - Fansa	10.0	,, ,,	,,	500
6	kathwada	7.5	,, ,,	,,	10,000
7	Umargoan (Nargol)	10.0	,, ,,	,,	10,000

TABLE 3. *Results of edible oyster survey along the Gujarat coast during 1991-'92*

Sl. No.	Location	Extent of area surveyed (ha)	Edible oyster species	Type of substratum	Estimated oyster population in numbers
1	Dwaraka (Gomti Ghat)	0.39	C. *gryphoides*	Rocky & muddy	100
2	Singadh	1.89	,, ,,	,,	100
3	Khalwada	7.50	,, ,,	,,	7500

densities and a fishery cannot be developed based on the harvest of these populations.

Experimental culture of *C. gryphoides*

Oyster spat of 5-10 mm length were reared in box-type cages of size 45 x 45 x 5 cm covered with nylon net. These cages were suspended from a floating bamboo raft and periodically cleaned to remove foulers and predators. The growth is fast during the first seven months. During the monsoon season growth is accelerated (about 25% more) when compared to other seasons. In the first year the average growth is 1-2 cm. Maturity is attained during the third year at an average size of 5 cm. Peak spawning occurs during June-August, followed by a secondary peak during November-December. The shell weight to meat weight ratio is 10:1.

Transportation of *C. madrasensis* from Tuticorin to Sikka

Since *C. madrasensis* grows faster and attains larger asymptotic size when compared to the locally available *C. gryphoides*, consignments of the spat of the former species were transported from the Tuticorin Hatchery of CMFRI to Sikka. The spat were brought by road from Tuticorin to Trivandrum, airlifted to Jamnagar and then transported by road to Sikka. Total transit time was 48 hours and the tin containers holding the oyster spat were opened only on reaching the destination.

In 1988 a total of 32,000 oyster spat were transported and the mortality was heavy at 85%. In 1990 various size groups of oysters (10 - 70 mm) were packed separately and transported. The spat measuring 10 - 20 mm gave good survival of 85% and the mortality was high in the larger oyster groups. During 1991 a total of 4,000 spat of about 10 mm length were transported and a high survival of 90% was obtained.

Growth of *C. madrasensis* in Gujarat waters

The transported spat were grown in cages laid in the intertidal region and have shown an average growth of 2.9 cm and 30 g in one year. It is concluded that *C. madrasensis* has interacted favourably with the prevailing environmental conditions in the Gujarat waters. Large-scale transplantation of *C. madrasensis* into Gujarat waters is suggested as it has greater economic value when compared to the three resident oyster species.

EDIBLE OYSTERS — PRESENT STATUS OF PRODUCT DEVELOPMENT AND DOMESTIC MARKET POTENTIAL IN INDIA

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Introduction

The fishery for oyster is worldwide. Extensive scientific studies on this species have taken place in our country also and the fishery, though in a moderate scale, is in existence along the coasts of Maharashtra and Kerala.

It is estimated that the world production of oysters is about a million tonne per annum. U.S.A, Japan and Korea are the largest producers of oyster. U.S.A. produces about 0.3 million tonnes while Japan produces about 0.2 million tonnes. In both cases, the bulk of the production is by culture.

Oysters are highly sought after delicacy of the developed world with a great export potential. The vast potential, both for capture and culture of oysters existing in our country especially in the light of ever-increasing need for protein food, calls for greater emphasis on its harvest and post-harvest technologies. The present paper therefore is an attempt to consolidate and present the experience of the Integrated Fisheries Project with regard to post harvest handling of oyster.

Processed oyster products — world scenario

Most of the edible bivalves which have acclaimed popularity in developed countries are recently becoming popular in developing countries as well. A considerable quantity of oysters are processed in frozen products, canned products, canned speciality products and dried products.

The table below indicates the quantity of processed oyster products produced worldwide during the five year period from 1985-'89.

(Qty. in tonnes)

Products	1985	1986	1987	1988	1989	Countries
Oyster meat frozen	3259	3930	2974	3978	3190	Canada, Korea New Zealand, USA, other nei.
Oyster dried	440	4175	3934	2779	2604	China, Korea, other nei.
Oyster meat	11595	9265	9875	8678	11618	China, Japan, Korea, New Zealand, USA
Oyster specially canned	1002	1531	1704	1389	1644	USA

(Source : FAO)

Global trade in oyster meat

Qty. in tonnes
Value in US $

	1985	1986	1987	1988	1989
IMPORT					
Fresh chilled and frozen					
Qty :	9756	9664	11379	18660	22680
Value :	24448	29357	37918	61884	76349
EXPORT					
Qty :	11125	14064	17775	18406	20040
Value :	24308	37829	56346	61908	67283

Domestic scenario

Oysters are local delicacies along our coastal belt, where they are accepted as a popular food item as the prices are reasonable. Bivalves in fresh form are not marketed in the interior regions of the country mainly due to the difficulties in transportation and storage. Canned and pickled products however, are found enjoying very good demand in the metropolis and small towns. The availability of the above resources has to be examined carefully for commercial processing and marketing.

Occurrence

The edible oyster is a sedentary animal found in intertidal rocky areas, muddy bays, backwaters, lagoons and creeks and extensive

areas of the east and west coasts of peninsular India which afford excellent habitat for the settlement and growth of these organisms. Naturally, there is a very large population of different varieties of oysters growing in these areas. There are essentially four important species of edible oysters which can be cultured under controlled conditions namely;

1. *Crassostrea madrasensis* - East coast oyster
2. *Crassostrea discoidea* - West coast oyster
3. *Crassostrea gryphoides* - Kutch oyster
4. *Saccostria cucullata* - Rock oyster

Of these, *Crassostrea madrasensis* is most widely distributed all along the coast of India and also along the west coast upto Karwar and can be easily farmed. Other species also can be cultured in areas where the wild stock is found in abundance.

Composition

Oysters are reasonably good source of protein and glycogen though the protein content is not as high as in the case of fin-fish. Following is the chemical composition of farmed oysters in comparison to fin fishes.

Parameters	Farmed edible oyster meat (%)	Fin fish (%)
Moisture	80.05	66-84
Protein	12.26	15-24
Glycogen	2.66	—
Lipids	—	0.1-22
Minerals	—	0.8-20
Ash	11.69	—

Oyster contains glycogen which gives its characteristic flavour. Though several workers have reported varying values for major constituents all reports unanimously show that these are good sources of protein, minerals and fat.

Research inputs in post-harvest care

Depuration is one key step that should precede processing of bivalves since they are filter feeders and there is bio-concentration from surrounding waters.

For purification either continuous or discontinuous system can be resorted to. In continuous system, 16-20% of sea water in the purification tanks is continuously renewed with running filtered sea water. In the discontinuous system the frequency of the water change is from two to three times a day (Fauvel and Pons 1978). Nayar and Mahadevan (1983) have designed and operated a simple method which ensures effective purification of oysters at the rate of 14,400 oysters per day. It is also advocated that a final holding of oysters in chlorinated sea water for one hour is effective in improving the bacterial quality of the meat.

Transportation of live oysters

Oysters will remain alive for several days if kept moist and wet. They can be packed in gunny bags which are kept moist from time to time. The method of packing should depend on the value of the product, journey time and the market for which it is sent (Stroud, 1980).

Samuel *et al.* (1987) have studied the possibility of transportation of live oysters over longer distances. About 21 kg of oysters were packed in gunny bags moistened with sea water and another 27 kg were kept in a rectangular aluminium fish box. Both were transported from Tuticorin to Cochin by road covering a distance of 340 km. The rate of mortality due to transportation and storage of live oysters outside sea water upto 24 hours at ambient temperature were found to be 0.45%, which is very negligible. Rajapandian (1987) has reported that no mortality was observed on transporting the material from Tuticorin to Madras covering a distance of 560 km.

Transportation of frozen oyster meat

IFP has conducted trials on frozen oyster meat transportation. The frozen oyster meat slabs were packed in master cartons and transported in an insulated truck from Tuticorin to Cochin covering a distance of 340 kilometres in about 14 hrs time. The frozen oyster meat was found to be in hard frozen condition on arrival at Cochin.

Shucking

Shucking is the removal of the meat from the shell of oysters either manually or by immersing the live animals in boiling water/sea water or by steam cooking for a minute until the shell of the animal gape or open.

Several methods have been devised to reduce the labour of hand shucking. These

include shearing of the hinge of beak of the oysters by guillotine and a wide range of treatments that cause the shell to gape open, including the use of chemicals, heat, cold vacuum, microwaves and lasers. Freezing of oysters before shucking is suggested by Stroud (1980) and placing the oysters in water just hot enough to open them as suggested by Nowak (1970). Yield of shucked meat is 3-4%.

Pre-treatment

Prior to freezing the shucked meat is given a pre-treatment. The meat is washed well and dipped in 1% salt solution containing 0.2% citric acid in 1:1 proportion for 10 minutes to reduce drip loss which is found to be in excess of 20% in the untreated oyster meat. Subsequently, the meat is frozen in slabs at —40°C.

In yet another method the shucked oyster meat is boiled in water for 1-2 minutes, cooled and packed with polythene lining and quick frozen to —30°C.

Studies on shelf life have shown frozen whole oyster to be in good condition after six months of cold storage at —30°C. The liquid within the shell acts as a glaze to protect the meat from dehydration. The meat of frozen whole oysters is suitable for preparing various dishes.

Research update on quality control

Many researchers have made in-depth study on the toxicological and bacteriological aspects of oysters and processed products thereof.

Heavy metal contents

Green discolouration of oysters has been attributed to copper and zinc pollution. Nambisan and Lakshmanan (1977, 1979, 1980 and 1983) have done extensive investigation in the heavy metal content of molluscan fish and toxicity. Lakshmanan (1988) studied the concentrations of Hg, Cu, Zn, Cd, Pb and Sn in commercially processed canned and frozen molluscan products and found that copper and zinc are comparatively in higher concentration, the overall mean being 56.88 and 178.6 ppm respectively. Toxic metals like Hg, Pb and Cd were below the permitted levels.

Indira Jasmine *et al.* (1988) have done the chemical analysis of the meat of *Crassostrea madrasensis* and found that the level of mercury was less than the accepted standard limit of 0.5 ppm in the edible meat.

Bacteriological sanitation

Being filter feeders the oysters harbour greater load of bacteria from the environment. The most common bacterial flora found in oysters are coliformes, *E. coli*, *Faecal streptococci* and occasionally pathogens like *Salmonella*, *Shigella*, *Vibrio parahaemolyticus* and *Vibrio cholerae*. Surendran *et al.* (1985) and Balachandran *et al.* (1984) have done extensive studies on the nature of molluscan microflora which reveal that oysters can create health hazards, if not properly processed. It has been observed that the bacterial count of cultured oysters and wild bed edible oysters ranged between 10^3 and 10^4 organism/ml of oysters fluid.

Update on processing and product formulation

Excellent possibilities in product formulation with oysters exist. In Japan both frozen and canned oyster products are in vogue. To mention a few are canned boiled oysters, canned smoked oysters in oil, canned seasoned oysters, boiled dried meat of oyster, battered and breaded frozen oyster meat.

In India, studies on the canning of edible oyster meat was carried out by Balachandran *et al.* (1984) . A variety of product has also been developed by Jayachandran (1988) of which oyster soup, oyster nectar, oyster curry and oyster sweat and sour pickle are commendable novel products.

Work done by IFP

Two products namely, canned smoked oyster in oil and oyster in brine from the farmed oysters have been developed and marketed by IFP. Various aspects of live transportation, frozen transportation, depuration, shucking, pre-treatment before freezing were all studied in detail.

Depuration and shucking

Depuration was done by laying the oysters in filtered sea water for 24 hours and relaying the oyster for one hour in sea water containing 3 ppm chlorine and finally keeping immersed in running filtered sea water for 3 hours for dechlorination.

Shucking was carried out manually after dipping the oysters in boiling water for 3 minutes.

Pre-treatment

The shucked oyster meat was washed well prior to freezing and dipped in 1% salt solution containing 0.2% citric acid for 10 minutes in the ratio 1:1. This is found to reduce drip loss from 20% to 16%.

Yield of frozen meat

Qty. of live oysters	:	1721 kgs
No. of oysters	:	9900 Nos
Boiling	:	3 mts. at 100°C
Qty. of frozen meat	:	78 kgs
Yield of frozen meat	:	4. 53%

Heavy metal contents and bacterial load were found to be within the acceptable limits as shown below :

Analysis of the oyster meat

Texicological test			*Bactertological tests*			
Mercury ppm	Copper ppm	Cadmium ppm	TPC/gm	*E. Coli*/gm	*Staphylo-coccus*/gm	*Salmo-nella*/gm
0.017	0.020	0.12	18000	N.D	N.D	N.D

N.D : Not detected

The procedure adopted for canning was as follows :

Oyster in brine

The shucked oyster is blanched in 3% brine containing 0.1% citric acid for 3-4 minutes and the blanched meat is cooled to room temperature. If frozen the meat is thawed at 0°C overnight and then blanched for 2-3 minutes. 85-90 gm of blanched meat is packed in quarter dingly cans (112 g net wt.) and a hot 2% brine with 0.1% citric acid is added to net weight. The packed cans were exhausted for 4-5 minutes, seamed and sterilized at 115°C for 22-25 minutes. The cans are cooled immediately, wiped to remove water on the can and warehoused.

Smoked oyster in oil

Frozen blocks of oyster meat is gradually thawed by keeping overnight in chill room at 0°C. The next morning, the oyster slabs are further thawed by immersing in water at 5°C for such duration just sufficient to thaw the slab so that meat can be separated from one another. The separated oyster meat is then immersed in 5% salt solution for 5 minutes and arranged on wire-mesh trays and smoked in a smoking chamber.

The smoking chamber has a smoke generating unit in which saw dust is burnt in an electrical hot plate. The smoke so generated is circulated inside the chamber where the oysters are arranged on trays. Thermostatic controls are provided inside the smoking chamber.

Smoking of oysters was done initially at 40°C for 30 minutes and subsequently at 70°C for 80-90 minutes. During the smoking operation, flavour of the oyster was improved due to the absorption of the volatile and other substances from the smoke, texture improved due to the partial dehydration and the colour of the oyster changed from bluish green to light brown.

The oysters thus smoked were packed in quarter dingly aluminium cans with tear off lid. Pack weight was 80 g in each can. Hot, double refined ground nut oil was used as canning medium, seamed, sterilized and warehoused.

These canned products were found highly acceptable to consumers when test marketed.

Potential for new product development

The R & D work done on oyster product development at IFP yielded a few promising products as described below.

Oyster pickle

The procedure involves frying of the depurated, shucked and washed meat in edible oil until the meat becomes light brown in colour. The fried meat is kept apart. Required quantities of ingredients like mustard, garlic, ginger, green chilly and curry leaves are fried together in refined oil for 2-3 minutes. At this stage, predetermined quantities of pepper powder, chilly powder, turmeric powder etc. are added followed by fried meat. The entire mass is boiled under stirring for a few seconds and removed from flame. When sufficiently cooled, vinegar is added, mixed and stored in glass bottles.

Dried oyster

The depurated, shucked and washed meat from oyster are blanched in 3-5% boiling brine

Analytical report on the organoeptic and bacteriological soundness of the products over a period of one year

Product	Parameters	Period				
		0	3 month	6 month	9 month	12 month
Smoked oyster in oil	1. Appearance	A	A	A	A	A
(Alum. cans)	2. Colour	B+	B+	B+	B+	B
	3. Flavour	A	A	B+	B+	B+
	4. Texture	A	A	A	A	A
	5. Disintegration	Nil	—	—	—	—
	6. pH	6.2	6.2	6.1	6.1	6.1
	7. Sulphide blackening	Nil	Nil	—	—	—
	8. Saltiness	Normal	Normal	Normal	Normal	Normal
	9. Colour of oil	Golden yellow	golden yellow	Golden yellow	Golden yellow	Golden yellow
	10. Turbidity	Nil	Nil	Nil	Nil	Nil

Overall score : A vey good product.

Microbiological examination

1. Mesophilic Aerobes	Nil	3. Thermophilic Aerobes	Nil
2. Mesophilic Anaerobes	Nil	4. Thermophilic Anaerobes	Nil

Analytical report of canned oyster in brine over a period of one year

	Oyster in brine	Period				
	(Alum. cans)	0	3 months	6 months	9 months	12 months
1.	Appearance	B+	B+	B+	B+	B+
2.	Colour	B+	B+	B+	B+	B+
3.	Flavour	A	A	B+	B+	B
4.	Texture	A	A	A	A	A
5.	Disintegration	Nil	Nil	Nil	Nil	Nil
6.	Sulphide blackening	Nil	Nil	Nil	Nil	Nil
7.	Saltiness	B+	B+	B+	B	B
8.	Clarity of brine	Clear	Clear	Clear	Clear	Clear
9.	Turbidity	Nil	Nil	Nil	Nil	Nil

Overall score : A vey good product.

Microbiological examination

1. Mesophilic Aerobes	Nil	3. Thermophilic Aerobes	Nil
2. Mesophilic Anaerobes	Nil	4. Thermophilic Anaerobes	Nil

A+	- Excellent	C+	- Satisfactory
A	- Very good	C	- Average
B+	- Good	D	- Below average
B	- Fair		

for 2-5 minutes depending on the size of the meat. The purpose of blanching is mainly to inactivate the enzymes, to reduce the bacterial load, and moisture content from the meat. The meat is dried in a hot air-drier. Drying is spread over 10 hrs to reduce the moisture content to the level of 10-15% in order to have sufficient shelf life. A shelf life of 6-8 months is observed for this product. Being a relatively new product, enough data on consumer preference is yet to be gathered.

Minced meat products

The oyster meat is sent through a meat cutter or meat mincer having a screen of 3 mm dia. to obtain coarse pieces of minced meat. Mincing may be done after blanching the meat in 2.3% salt solution for 3-4 minutes. The minced meat thus obtained may be packed in duplex cartons with polythene lining and frozen in a contact plate freezer and stored below —20°C.

This meat of oyster can be mixed with mince fish in the ratio 1:2 and new products like cutlets, kababs and fish balls can be developed.

Battered and breaded IQF meat

Oyster meat is useful for production of battered and breaded products. The shucked oyster meat is to be blanched mildly in boiling brine of 2-3% for 2-3 minutes. The blanched meat is dipped in a batter mix made of wheat flour, salt, sugar, spices, vegetable oil etc. as required and breaded with bread powder and frozen to —30°C and stored below —25°C.

Canned products

Oyster meat can be canned in curry, in masala and also with mixed vegetables. Experiments at IFP yielded good tasty products.

Minced meat

The shucked meat may be used for mincing directly or after mild blanching using a meat mincer. The minced meat is packed in suitable containers. The juice that runs out of the minced meat my be collected, boiled and added into the cans as liquid medium and subsequently exhausted, seamed and sterilised.

The canned minced meat may be used for making soups, cutlets, meat balls etc.

Soups/soup stock

During the mincing operation of oyster a considerable quantity of liquid flows out from the meat. Some quantity of this liquid is added into the containers as the medium but a good quantity of liquid may still be wasted.

This liquid may be boiled with spices, tomatoes, onions, salt etc. and canned as soup or nectar. The hot liquid is filled into the containers, seamed and sterilised.

The soup/nectar may be used as a soup stock for preparing soup or as a flavouring agent for other preparations.

Oyster chowder

The shucked oyster meat is thoroughly washed and then chopped in a grinder or meat cutter. Diced potatoes and bacon are added. Other ingredients like tomatoes, onions, white pepper and salt are also added in stages. Then the ground oyster meat together with all the ingredients is boiled for 10 minutes and filled into the containers under stirring. The containers are then exhausted, seamed and sterilised.

Oyster extracts

When oysters are shucked by steaming and also where the oyster meat is blanched, considerable amount of liquid/juice is released from the meat. The liquid is collected, filtered and concentrated by boiling. The concentrated extract is filled into the containers, exhausted, seamed and sterilised. Oyster extract can be used as a food for convalescents and invalids.

Domestic marketing of oyster products

Edible oysters are usually marketed as live oysters with shell, shucked oyster meat, frozen oyster meat and canned oyster meat.

Marketing of live oysters

Eating oysters in live condition is a fancy in alien countries. With number of tourists visiting India increasing every year marketing of live oysters will be highly profitable and would fetch comparatively higher prices. The purchasers of live oysters will be mainly star hotels in metropolitan cities.

In the experiments conducted on transportation of live edible oysters packed in gunny bags

moistened in the seawater, it was found that oysters remained alive outside sea for upto 30 hours at ambient temperature. The oysters on reaching the destination can be relaid in seawater and utilised for marketing in live condition. Hence, it is thought that marketing of live oysters has a good scope when done on a commercial basis, with proper technical backing.

Marketing of canned oyster meat

Marketing of canned oysters was a great success despite the novelty of the product. The canned oyster meat in brine and smoked oyster in oil were released for sale in many cities and towns in India along with other canned products of the Project. Both the products met with appreciable offtake and the same often ran into short supply due to limited raw material availability.

Marketing strategy adopted

Pricing policy

The selling price for canned oyster products was fixed on no-loss no-profit basis taking into consideration the cost of inputs only with intention of popularising the non-conventional types of fishery products in the domestic market.

1) *Cost of production of canned smoked oyster in oil*

1. Name of product	:	Smoked oyster in oil (200 gm) No. 6
2. Raw material		
i) Oyster meat 200 kg @ Rs. 30/kg	:	Rs. 6000.00
ii) Refined oil 27 kg x 60	:	1620.00
iii) HSD oil 470 l x 7/-		3290.00
iv) cost of cans No. 6, 540 x 9/-		4860.00
v) Labels 534 x 0.75		400.50
vi) Teepol, cotton waste etc.		30.00
		: Rs. 16,200.50
3. Handling charges - Rs. 230/t (included in the raw material)		
4. Labour charges		Rs. 574.20
5. Canning overheads @ Rs. 4.76/kg for 200 kg		952.00
6. Marketing overhead @ Rs. 2/kg for 534x0.2 kg		213.60
		Rs. 17,940.30
7. Product obtained :534 cans (No.6) of smoked oyster in oil		
8. Price per can of smoked oyster in oil :		
= Rs. $\frac{17940}{534}$		= Rs. 33.59
Rounded to Rs. 33.60		

2. *Cost of production of canned oyster in brine*

1. Name of product	:	Oyster in brine No. 6
2. Raw materials :		
i) Oyster meat 100 kg @ Rs. 30/kg.		Rs. 3000.00
ii) HSD oil 230 lit. x 7/-		1610.00
iii) Cost of cans 380 x 9/-		3420.00
iv) Labels 380 Nos. x 0.75		285.00
v) Teepol, cotton waste etc.		20.00
vi) Powder salt 2 kg x 2/-		4.00
		Rs. 8339.00
3. Handling charges (included in the cost of raw material)		
4. Labour		287.10
5. Canning overheads @ 4.76/kg		476.00
6. Marketing overheads @ Rs. 2/kg		152.00
		Rs. 9254.10
7. Product obtained : 380 cans (No. 6) of oyster in brine		
8. Price per can of oyster in brine :		
Rs. $\frac{9254.10}{380}$		= Rs. 24.35
Rounded to Rs. 24.40		

Marketing through fisheries corporations/ departmental stores

The IFP is marketing its fish and fishery products by direct sales to consumers and also through State Fisheries Development Corporation, departmental stores, super bazars etc. on a preferential basis in order to make available the products at reasonable prices.

Efforts are also made to supply the products through private retail outlets in order to ensure wider availability of products throughout the country.

Seafood special drive

The IFP has been organising 'seafood special drives' in various cities and towns, as a part of product popularisation on non-conventional varieties of fish and fishery products in the domestic markets in India. During the special drive period, advertisements were inserted in dailies having wide circulation in the region both in vernacular and in English, giving details of the rage of products, stores/shops where they are sold, nutritional qualities of the product, advantages of using canned food etc. This type of publicity had very good effort as could be judged from the following days' clientele. Catching posters were prepared and displayed in the shops and stalls and consumers were also provided with recipe leaflets.

Thanks to the efforts taken by IFP, the canned oyster products, other canned fish and dried fish products are being very well accepted in places like Delhi, Bombay, Calcutta, Madras, Bhopal, Patna, Ranchi, Dehradun, Mussourie, Chandigarh, Manipur, Nagaland, Poona, Bangalore, Mysore, Mangalore, Ooty etc. It is proposed to further intensify the projects' efforts in this direction.

Conclusions and recommendations

From the foregoing, it can be seen that processed oyster products enjoy a good domestic demand and also have great export potential. The infrastructure available for large scale ventures in oyster culture could be effectively exploited only when the marketability of the processed oyster products are adequately demonstrated. It is essential that the R & D efforts already made in the areas of processing and marketing of oysters by CIFT, IFP and other agencies are synthesized into economically and technically perfect process flows. A pilot scale product development and marketing campaign could then be taken up by IFP consuming a substantial portion of the wild oyster landed and those being cultured at present by CMFRI. The results of such a sustained work after an year would be made available to potential entrepreneurs with all data on the component activities so as to enthuse them into taking up the vocation of oyster culture.

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OVERSEAS MARKET PROSPECT FOR OYSTER MEAT AND OYSTER PRODUCTS

Introduction

Among the molluscan shellfish, oysters are considered very delicious and also nutritious with appreciable amounts of glycogen, proteins, vitamins A, B and minerals. The succulant flesh of the common edible oyster has graced the tables of gourmets and gourmands alike since time immemorial. Its reputed powers range from aphrodisiac to restorative and was often prescribed by the 19th Century doctors in North America. Oysters are reportedly cultured by the ancient Romans, and old woodcuts show oyster harvesting in Japan.

The ubiquitous oyster's occurrence on practically all coasts, temperate and tropical, is undoubtedly responsible for its popularity. Even without refrigeration it can remain alive and wholesome for several days allowing it to be transported to distant markets. While oysters are considered a luxury product in France (and in the rest of Europe), they have been quite inexpensive in the major landing countries viz. USA, Japan and Rep. of Korea.

Indian Market for oyster products

In India till recently oysters were consumed in the coastal areas only, mainly by fisherfolk and a few others to a limited extent. However, with the growing awareness for more nutritious food, demand for oyster meat has risen in the country among all classes of people. *Crassostrea madrasensis* is the common backwater oyster found in all estuaries and backwaters on the east-

coast, but confined mostly to the southern region on the west coast. It occurs in abundance particularly in Ennore and Pulikkat areas in Madras, Sonapur in Orissa and the Vembanad Lake in Kerala. *C. cucullata* is the common rock oyster of India found in all the intertidal rocks of the east coast and the west coast.

As oyster culture is practiced in many countries to meet their domestic demands, no intensive farming is practiced in India for export market. Small scale farming is practised to meet the domestic demands of the country. However, since 1981 oyster shell powder is exported to the Arab countries, as detailed below

Q : Qty in tonnes
V : Value in Rs. lakhs

		Export of oyster shell powder from India					
Country		1985	1986	1987	1988	1989	1990
Bahrain	Q :	100.00	618.00	947.00	—	—	—
	V :	0.62	4.39	6.54	—	—	—
Kuwait	Q :	100.00	—	101.00	—	—	—
	V :	0.62	—	0.69	—	—	—
Saudi	Q :	—	—	200.00	—	—	—
Arabia	V :	—	—	1.28	—	—	—
Oman	Q :	—	—	200.00	—	—	—
	V :	—	—	1.22	—	—	—
UAE	Q :	—	98.00	—	—	160.00	—
	V :	—	0.91	—	—	1.11	—
Total	Q :	220.00	716.00	1448.00	—	160.00	—
	V :	1.23	5.30	9.73	—	1.11	—

World oyster markets

Many countries harvest oysters from natural beds or culture then commercially, but the output from only four countries viz. Korea Rep., japan, USA and France together accounts for over 78% of the total world landings, as seen below :

World Oyster Landings (in shell) (in '000 tonnes)

Country	1987	1988	1989
Korea Rep.	303.2	298.7	243.0
Japan	258.8	271.0	256.3
USA	217.6	167.7	158.4
France	138.2	137.8	139.8
China	65.5	74.0	73.2
Mexico	50.7	56.1	56.3
Taiwan (PC)	21.2	28.5	28.5
Philippines	16.3	15.9	17.3
Total	1109.9	1093.7	1020.0

The world landings of oysters have stood at one million tonnes during the past decade. Major marketwise analysis is given below :

1. *Korean oyster market*

The Rep. of Korea was the main oyster producing country in the world till 1988 but in 1989 Japan became the topper. Most of the production comes from culture fishery, *Crassostrea gigas* being the leading species. Though oyster culture was quite significant at the end of last century, production for exports began in the 1960s. The Rep. of Korea, helped by low labour cost, has successfully developed its exports of oysters, (Fresh/Frozen meats) to Japan and USA and canned products to N. America, Australia, Hong Kong etc. Dried (salted) oysters are also exported to some Asian countries, mostly to Hong Kong.

Canned oyster exports from Korea (in MT)

Country	1984	1985	1986	1987	1988
USA	3473	5244	8732	6683	6442
Canada	259	923	1609	842	1322
Australia	351	679	826	541	794
Hong Kong	121	13	127	34	5
Others	209	241	363	416	418
Total	4413	7100	11657	8516	8981

The Korean Government, aware of the potential challenges from the neighbouring countries, viz. China, Thailand, Philippines etc. has recently enforced minimum export prices to ensure quality of the product exported. Despite the spectacular expansion of Korean exports, domestic consumption is also growing.

2. *The Japanese oyster market*

The Japanese oyster landings (all from culture) have been stable for several decades, averaging 250,000 tonnes. They are mostly shucked and sold fresh. Consumption is stable at 0.30 kg meat per capita and limited to the winter period. Due to the exceptionally high productivity of Japan's intensive culture farms, oysters are not an expensive product in the domestic market — average price US $ 1.30 - 2.50/kg and US $ 5.00 - 8.00/kg depending on the suitability for raw consumption or for cooking.

Japan was traditionally an exporting country for canned oysters, but the industry suffered due to stiff competition from other Asian countries, especially the Rep. of Korea which managed to produce at a lower cost and export significant quantities of fresh/frozen oyster meat to Japan. Exports of fresh/frozen oysters, although limited (200-300 tonnes) have continued to the traditional markets like UK and Australia. Only a marginal trade, primarily for Japanese restaurants and shops in foreign countries is expected to continue in the future.

Japan Oyster Exports (in MT)

Country	1983	1984	1985	1986	1987	1988
Live, fresh, frozen						
Australia	43	81	84	77	45	39
UK	49	37	69	75	86	61
Hong Kong	21	148	48	37	46	33
Singapore	103	26	70	12	51	21
Others	30	56	40	83	14	15
Total	246	348	311	216	242	206
Canned in oil						
USA	180	271	246	146	9	—
Others	13	83	52	18	18	44
Total	313	354	298	164	27	44
Canned in water						
USA	577	835	1081	639	530	809
Others	106	77	101	43	51	126
Total	683	912	1182	682	581	935
Salted/dried						
Hong Kong	97	88	101	96	26	na
Others	28	36	19	35	15	na
Total	125	124	120	131	41	na

Despite the fact that Japan is the second most important consuming country in the world, imports have been so far very limited, despite the successful export industry in the nearby Rep. of Korea. The demand for oysters in Japan is likely to stay fairly stable in the near future and continue to rely exclusively on domestic supplies. This outlook could change if the degradation of environmental conditions become very serious in coastal areas, affecting the oyster culture industry.

3. *The US oyster industry*

Despite the fact that US seafood consumption rose over the years, the oyster meat consumption declined from 0.19 kg in 1960 to 0.15 kg in the 1980s. This was reportedly due to the sharp decline in landings. About 90% of the US domestic production is shucked for the fresh/frozen market and the remainder goes for canning. Shucked oyster price ranged from US $ 11.00/kg for standards to US $ 15.00/kg for selects.

Traditionally the US consumers prefer the Atlantic Oyster (*Crassostrea virginica*) to the Pacific cupped oyster (*C. gigas*). However, with the decline of the Atlantic coast industry and the expansion of the Pacific coast oyster industry, the US consumers are becoming more familiar with the Pacific cupped oyster. With the increasing desire in the US consumers to eat more natural food, market for oysters in half shell has expanded recently in USA. The oysters in half shell recently popular in USA. The oysters destined to be sold in the half-shell are usually cultured in trays or by other off-bottom techniques. These oysters are small with a clean shell and are more appealing compared to wild oysters. Most adapted strain is the Kumamoto oyster which is deep cupped and has a very delicate taste. This type of product is going mainly for restaurant trade and commands premium price in the market.

Imports of Oysters have climbed steadily since 1980, due to the decline of the domestic production and the availability of cheap imported frozen and canned product from Asian countries, especially Rep. of Korea. Now there is also a growing demand in the food service market, especially for blocks of IQF meat.

US Oyster Imports (in 1,000 MT)

Country	1983	1984	1985	1986	1987	1988
Fresh/frozen						
Korea Rep.	1.2	1.1	1.6	1.1	1.7	1.5
Canada	0.1	0.4	0.5	0.5	0.7	0.8
Japan	0.2	0.2	0.3	0.2	0.1	0.1
Others	0.1	0.1	0.0	0.1	0.1	0.1
Total	1.6	1.7	2.4	1.8	2.5	2.5
Canned in brine						
Hong Kong	1.8	4.0	5.0	5.4	5.5	4.6
Korea Rep.	3.9	2.9	3.3	4.4	4.8	3.2
Japan	0.6	0.6	1.3	0.8	0.5	0.9
Others	0.1	0.2	0.1	0.4	0.2	0.2
Total	6.3	7.7	9.7	10.9	11.0	8.9
Canned/smoked						
Korea Rep.	2.0	2.0	2.8	3.4	3.6	3.4
Japan	0.2	0.3	0.4	0.2	—	—
Others	0.0	0.0	0.0	0.1	—	—
Total	2.2	2.3	3.2	3.6	3.7	3.5
Total canned	8.5	10.0	12.9	14.5	14.7	12.4

With the US oyster market turning to more high quality products, cultured oysters because of its homogenous grading and quality, will receive a premium which may supplant the wild product in importance.

French oyster market

France is the major oyster producing country in Europe. Nearly all output is cultured; oyster farming is a small artisanal and traditional family activity. About 97% of the total production is accounted by Pacific cupped oyster (*Crassostrea gigas*).

French oyster consumers prefer to eat the product raw, on the half shell. Oyster marketing is a highly specialised business and the trade is strictly controlled by a health register which oversee packaging and distribution.

France is traditionally exporting oysters to other West European countries as part of the popular French cuisine.

Live/fresh oyster exports from France (in MT)

Country	1983	1984	1985	1986	1987	1988
Flat oyster						
Spain	103	—	—	—	363	303
Germany FR	44	—	—	50	133	169
Switzerland	113	110	135	163	163	33
Others	181	0	132	113	190	60
Total	441	110	267	326	849	565
Cupped oyster						
Italy	284	501	646	1008	1846	2725
Belgium	290	329	325	468	437	436
Germany FR	77	86	182	511	234	217
Switzerland	85	79	102	72	126	209
Spain	—	162	338	317	110	76
Others	164	108	194	153	252	230
Total	900	1265	1787	2529	3005	3893

Overstocking of oysters is often considered as a major reason for the decrease in the French oyster production. Due to expansion of urbanization, tourism and industry, less unpolluted sites remain for shellfish culture. The prospects are thus not very prospective for oyster culture in France. Also demand for oyster seems to stagnate and younger consumers prefer to buy easy to prepare food like smoked salmon, foie-gras etc. In addition, other European countries have begun to develop their own oyster culture and will probably import less in the near future.

Canadian oyster market

The Canadian Oyster landings were somewhat steady at about 6,000 tonnes in the recent years.

Distribution and consumption patterns in Canada are quite similar to that of USA. Consumption of frozen shucked oyster is limited and occurs mainly during summer months when the fresh product is in short supply or of poor quality. For the half shell, the restaurant trade represented over 80% of the sales and 15% for the retail market.

Canada also imports about 1500 tonnes of canned oyster from Asia, mainly from Rep. of Korea.

Canadian oyster Imports (in MT)

Country	1983	1984	1985	1986	1987	1988
Fresh/frozen						
USA	707	619	624	872	720	490
Korea Rep.	*	*	*	*	108	*
Others	13	25	86	53	10	109
Total	720	644	710	925	838	599
Canned						
Korea Rep.	1125	1361	1395	1547	1108	1696
Others	89	60	32	67	38	50
Total	1214	1421	1427	1614	1146	1746

*Included under "Others"

With the development of oyster farming in Canada there are good prospects for exporting *Crassostrea virginica* to USA where there is a growing deficit of the product and *Ostrea edulis* to Western Europe where this species is very popular and fetches a high price because of the present low availability (disease problems).

The Hong Kong oyster market

Almost all oysters cultured in Hong Kong are marketed fresh and shucked, and consumed half in restaurants and the other half at home. Wholesale prices of fresh shucked oysters averaged to US $ 6.30 (1988). Hong Kong is the world's most important market for dried and salted oysters because of the high demand by the cantonese community which forms the majority of the population.

About 500 MT of fresh/frozen oysters and about 1500 MT of dried oysters are annually imported in Hong Kong to satisfy the domestic market. Significant processed quantities are re-

exported world-wide for the Chinese ethnic food trade.

Hong Kong is expected to remain the key market for salted/dried oysters. Hong Kong exports every year over 13,000 MT of oyster sauce worldwide. The exports of salted/dried oysters are expected to expand further as no difficulties are foreseen since landings in major supplying countries (Japan, Rep. of Korea and China) are stable or increasing.

Other minor markets

Other markets where the oyster industry is progressing are New Zealand and West European countries like Netherlands, UK, Ireland, Spain, Italy and Greece. While the European Countries trade each other, New Zealand oysters are exported mainly to Australia.

Export prospects for oyster meat from India

Oysters are mainly consumed by populations which have been familiar with the product for a long time, often because they produce it. Because the main oyster producing countries are at the same time the major consuming countries, the international trade of oysters is rather limited, about US $ 150 million.

Oyster Consumption in selected countries (in MT)

Country	Domestic	Imports	Exports	Supply	Consumption (per capita)
Hong Kong	0.2	3.0	1.0	2.2	0.40
France	18.0	—	1.0	17.0	0.30
Japan	40.0	—	3.0	37.0	0.30
USA	18.0	22.0	0.5	39.5	0.17
Korea Rep.	40.0	—	25.0	15.0	0.35

International oyster trade (byproduct form)

Q : in '000MT
V : in Million US$

Product	Quantity	Value	Markets
Live, in shell	7.0	20	West Europe,
Fresh shucked	2.0	20	USA, Canada, Australia,
Frozen shucked	6.0	30	Japan, USA, Hong Kong,
Canned	14.0	65	USA, Canada, Australia,
Salted/dried	1.5	15	Hong Kong
Total	300.0	150	
	(equivalent live weight)		

Most of the international trade is for frozen or canned meat products, which takes place predominantly between South East Asian countries and North America, where imports are substituting for the declining domestic output.

USA, Canada, Japan and Hong Kong are all potential markets for oysters. USA, due to the decline in production (pollution problems) is in high demand for quality cultured oysters. Though Japan and USA are the two important markets for Indian marine products, Indian oysters may not find a steady market here because of the easy availability of fresh oysters from the neighbouring countries viz. China, Korea Rep., Mexico etc.

have also reported that the mussels always harboured greater bacterial populations than the aquatic environments. Varma *et al.* (1988) have studied the quality of frozen boiled clam meat meant for export. In general the commercial frozen boiled clam belonging to *Villorita cyprinoides* from Cochin are contaminated with faecal indicator and pathogenic organisms than in that belonging to *Katelysia opima* from Quilon. 5.4% of the samples belonging to the *Villorita* sp. also contained *Salmonella*. Iyer & Varma (1987) have also isolated *Salmonella* from mussel. Indicator bacteria has also been isolated from mussel (Gore *et al.*, 1992).

b) *Metals*

Since the molluscan shellfish filter large quantities of water during their feeding process, there are chances of accumulation of toxic heavy metals in their body, if the environment is polluted with toxic metals. Lakshmanan and Nambisan (1986) have reported trace metals in mussel collected from Narakkal and Mahe. According to them the mussel contained mercury 0.06-0.09 µg/g, copper 1.367 to 5.652 µg/g, zinc 9.36-18.75 µ/g and lead 0.64-1.83 µg/gm. Nair and Nair (1986) have also reported the presence of Cd, Cu, Fe, Mn, Zn and Hg in oysters collected from Cochin backwaters.

c) *Other contaminants*

Radhakrishnan *et al.* (1986) have reported the presence of chlorinated pesticides in mussel collected from Calicut. They have reported that the level of these pesticides in mussel is two times more than that in fish.

d) *Paralytic shellfish poisoning*

Paralytic shellfish poisoning (PSP) is caused by a neurotoxin produced by certain marine dinoflagellate algae. Various mussels, clams, scallops etc. become toxic if they feed on toxic dinoflagellates. Incidences of PSP has long been known along the Pacific and Atlantic coasts of North America and Canada where many fetal cases have been recorded (Prakash *et al.*, 1971). Out breaks have also been reported from Western Europe (Luthy, 1979) and Japan (Hashimoto, 1979). From India Indrani Karunasagar *et al.* (1984) have reported incidence of PSP after consumption of clam from Kumble near Mangalore.

Quality standards

a) *Indian*

No Indian standards are available for molluscan shellfish products. However, the Export Inspection Agency has prescribed some limits for frozen clam meat which come under the compulsory preshipment inspection of EIA. The limits are *E. coli* 10/gm. Coagulase positive staphylococci 100/g and total bacterial count 2 lakhs/g for raw consumption and 5 lakhs/g if the product is for further cooking.

b) *Overseas*

The quality standards for oyster is given in Table 1 and the quality standards for molluscan shellfish in general are given in Table 2. In general total bacterial count ranges from 1-5 lakhs/g, *E. coli* MPN index 230/100 g and *Salmonella* absent. USA has also prescribed a limit for paralytic shellfish poison at 80 mcg/ 100 g.

Code of practice

Code of practices have been prescribed by Codex Alimentarius Commission of FAO (Codex CAC/RCP 18-1978. Recommended International Code of hygienic practices for molluscan shellfish) and National Health and Medical Research Council of Australia.

Code of practices recommended

1. *Use of near-shore water for washing purposes*

Near-shore water shall not be used for washing the catch or the fish-contact surfaces. The harbour water is often polluted with land sewage and harmful enteric organisms.

2. *Sorting of catch on sea beach*

In certain areas of the country the landed fish get sorted on the sea beach where even presence of faecal matter has been noted. This is a very important source for contamination of the catch with pathogenic microorganisms.

3. *Washing of utensils and fish-contact surfaces*

On constant use, the utensils get a coating of fish slime which can harbour harmful bacteria. The utensils and fish-contact surfaces shall be washed at frequent intervals using suitable detergents like teepol, spectrol etc. followed by disinfection using sodium hypochlorite solution having a residual chlorine strength of 100 ppm giving a minimum contact time of 15 minutes.

QUALITY CONTROL OF MOLLUSCAN SHELLFISH PRODUCTS

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The export of molluscan shellfish products from India is picking up momentum since the last few years. At present among the molluscan shellfish products exported from our country frozen boiled clam meat forms the major item. In 1991 India has exported 1,232 tonnes of frozen boiled clam meat valued at Rupees 3.7392 crores. The other products being exported are frozen mussel meat, dried clam, dried mussels, canned mussel meat and oyster shell powder (Annexure-I MPEDA, Cochin). Clams, mussels and oysters are also processed in other forms like pickles, marinades, etc. but are mainly utilized for local consumption.

General quality problems

a) *Bacteriological*

Molluscan shellfish filter large volumes of water during their feeding activities and as a result they concentrate microorganisms including pathogens within their bodies. Most of these pathogenic microorganisms are of faecal origin and cause great health hazards. Surendran *et al.* (1986) have reported that mussels collected from shallow waters off Calicut have a total bacterial population of 103 to 106 per gram, faecal coliforms 36 to 2150/g, *E. coli* 0 to 115/g and faecal streptococci 30 to 1800/g. They

have also reported that the mussels always harboured greater bacterial populations than the aquatic environments. Varma *et al.* (1988) have studied the quality of frozen boiled clam meat meant for export. In general the commercial frozen boiled clam belonging to *Villorita cyprinoides* from Cochin are contaminated with faecal indicator and pathogenic organisms than in that belonging to *Katelysia opima* from Quilon. 5.4% of the samples belonging to the *Villorita* sp. also contained *Salmonella*. Iyer & Varma (1987) have also isolated *Salmonella* from mussel. Indicator bacteria has also been isolated from mussel (Gore *et al.*, 1992).

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On constant use, the utensils get a coating of fish slime which can harbour harmful bacteria. The utensils and fish-contact surfaces shall be washed at frequent intervals using suitable detergents like teepol, spectrol etc. followed by disinfection using sodium hypochlorite solution having a residual chlorine strength of 100 ppm giving a minimum contact time of 15 minutes.

TABLE 1. *Quality standards for oysters*

		Japan		Australia (1)		USA (2)	I C M S F	
1.	Total viable count Max/g	5.0×10^4	Raw oyster for uncooked consumption	1,00,000	Fresh & frozen		5,00,000	Fresh & frozen
2.	*E. coli* (MPN) Max.	230/100 g		2.5/g	AS 2788		230/100 g	
3.	Arsenic ppm			1.0	For all			
4.	Cadmium ,,			2.0	molluscs			
5.	Copper ,,			70.0	includ-			
6.	Lead ,,			2.5	ing			
7.	Mercury ,,			0.5	oyster			
8.	Zinc ppm			1000 for oyster				
9.	Paralytic shell-fish poison					80 mcg/100 g		

Ref : 1) Infofish International 4/90, p 59-60.

2) Codex Alimentarious Commission CAC/RCP 9-1976.

3) Microorganism in Foods. II International Commission on Microbilogical Safety of Foods.

Canada

Fresh or frozen oysters are not permitted entry from any country except those which have sanitary control programmes which have been approved by Canadian Ministry for Fisheries and Oceans. (Ref : Infofish International No. 5/90 p 56).

TABLE 2. *Quality standards for molluscs*

Country	TPC	*E. coli*	*Salmonella*
Denmark	at 20°C 5 days Max. 1,00,000/g	Not present in any of 10 samples	Not present in any of 10 samples
France	—	Less than 1/ml (for raw eating) Less than 2/ml (for eating after cooking)	Absent
Italy	—	MPN 160/100 ml in 90% samples collection centre; " 500/100 ml in 10%	—
U. K.	—	MPN 600/100 g — in Market 0-2/ml Sale permitted 3-4/ml 5/ml Temporary prohibition 6-15/ml 16/ml — Sale prohibited	
U. S. A.	5,00,000/g at 35°C	MPN 230/100 gm	Paralytic shellfish poison 80 mcg/100 g in the edible portion of raw shellfish meat

Ref : Codex Alimentarious Commission CAC/RCP 9-1976.

Bamboo baskets, cane baskets and such other containers that are difficult to be cleaned shall not be used to store/transport fish.

4. *Chlorination of water supply*

It may be made a practice to use only chlorinated water (10 ppm) in the fish processing factories. Many of the enteric organisms are water-borne and, as considerable amount of water is used in the seafood industry, chlorination of water is to be given top-priority. In a set up like ours, where the material is handled in primary process centres situated in villages that are not provided with municipal water, chlorination of the water supply is one of the major recommendations.

5. *Handling of ice*

Considerable quantity of ice is being used in the seafood industry and any bacterial defect in the ice will reflect on the microbial quality of the processed product. Ice is to be prepared from chlorinated (10 ppm) water and to be stored and handled in such a way that bacterial contamination can be avoided. In some of the primary processing centres, ice blocks are stored on the

floor of the processing hall itself. This practice has to be discontinued in the interest of the quality of fishery products being processed and exported from this country.

6. *Worker's hygiene*

Before starting work, all fish handlers shall wash their hands from elbow down using soap followed by disinfection using water chlorinated to a level of 100 ppm. The process may be repeated at any time they leave the processing hall and return for work again or at any other time their hands become otherwise contaminated.

7. *Workers' health*

Workers can be healthy carriers of may dangerous bacteria like *Salmonella* or *V. cholerae.* These workers will contaminate the material they handle thereby creating public health problems. Many typical examples of such contamination from workers have been reported in the literature. In our country, so far, there is no system of medical examination of fish-handlers to trace out the carriers and to treat them in the proper way. This is another area which requires immediate attention.

8. *Rodent control measures*

Rodents may carry many diseases such as plague, endemic typhus fever, infectious jaundice, *Salmonella* food poisoning etc. Most of these are transmitted from the infected rodents to man by lice, mites or by contamination with rodent urine and excreta. There are many reports in India indicating isolation of *Salmonella* and Vibrios from rodents and well lizards. All possible precautions have to be taken to prevent the entry of rodents to the processing hall.

Multiplication of rats and mice depends upon the food and harborage available. Therefore, the only permanent and lasting means of control is the elimination of food source and harborage. The processing hall should be made rodent proof. As a guide for rodent proofing it may be noted that :

i) Rodents can gain entry through a $^1/_2$ inch hole.

ii) They can climb vertical wires.

iii) They can climb outside vertical pipes not more than 4 inches in diameter.

iv) They can jump 26 to 36 inches both horizontally and vertically from a flat surface.

v) They can drop 50 feet without being killed.

9. *Fly control measures*

Flies will transmit a number of bacteria to the food from the surroundings. Proper fly-proof nets have to be used in the processing units to prevent the entry of flies.

10. *Separation of process*

On no occasion a finished product should come in contact with the raw material. It is dangerous to handle cooked and uncooked fishery products in the same processing hall. Separate team of workers should handle such products in separate rooms using separate utensils.

11. *Waste disposal*

The disposal of wastes from food processing plants often presents special problems on account of their relatively high content of organic matter and their high biochemical oxygen demand. There should be an efficient system for disposal of waste material from the factory premises. Accumulation of waste will attract flies and rodents also apart from making the premises dirty.

12. *Toilet facilities*

Plant hygiene also includes proper construction and supervision of toilet facilities. Such facilities should be adequate in number and should be cleaned and disinfected at frequent intervals. Toilet should be atleast 100 feet away from the processing hall. The roof-wall joint of the lavatories should be tight so as to avoid entry of flies and rodents. The door of the lavatories should be fitted with self closing doors. The recommended number of toilet facilities may be as follows :

Number of persons/shift	Number of facilities required
1 to 9	1
10 to 24	2
25 to 49	3
50 to 100	5
Over 100	1 each for additional 30 persons

The toilet seats and the floor of the toilet rooms should daily be scrubbed with a detergent followed by disinfection using chlorine solution of 200 ppm strength.

13. *Depuration*

Depuration is a process by which most of the pathoorganisms/ metals accumulated in the molluscan body can be removed. The following processes are recommended.

a) Shell stock intended for should remain out of water for not more than 48 hrs.

b) Sea water used for depuration should be clean and should be of a salinity necessary for normal physiological functioning of the shellfish. There should not be any toxic substances in the water.

c) The water used for depuration should be disinfected with UV light, or other suitable techniques.

d) In turbid condition the water should be pre-filtered.

e) The flow of water used in depuration tank should be such that a complete change of water occurs every 30 mts.

f) The shell stock should be laid out at a density which will permit them to open and undergo depuration.

g) The oxygen content of water should be maintained.

h) The water temperature during depuration should be maintained. Tanks should be protected from direct rays of sun.

i) The equipments in contact with water should be constructed of non-porous, non-toxic materials.

j) To avoid recontamination of shell stock undergoing depuration, unpurified shell stock should not be placed in the same tank.

k) Shell stock undergoing depuration should remain immersed for a minimum period of 36 hrs.

l) After depuration the shell stock should be washed in potable water.

m) Depuration tanks should be drained cleaned and disinfected.

n) Proper registers should be maintained regarding depuration.

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ANNEXURE - 1. *Export of molluscan shellfish*

Qty : in tonnes
Value : Rs. Thousand

Item		1987	1988	1989	1990	1991
Fr. Boiled clams	Q	730	311	329	414	1232
	V	12,975	4,385	5,369	7,558	37,392
Fr. Mussel meat	Q	6	7	—	6	13
	V	119	160	—	131	328
Dehydrated clam meat	Q	—	—	42	107	164
	V	—	—	933	2,546	4,789
Dried mussels	Q	4	3	—	—	—
	V	109	89	—	—	—
Canned mussel meat	Q	—	—	—	4	—
	V	—	—	—	76	—
Oyster shell powder	Q	1,448	—	160	—	16
	V	973	—	111	—	35

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