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MUSSEL CULTURE

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ABSTRACT

The annual production of mussels, which was 10,000 tonnes in the early 1990's, doubled by 2002 through increased exploitation and farming. Among the maritime states, maximum production is along the Kerala coast. C.M.F.R.I has conducted demonstration programmes in open sea and estuarine farming of mussels by using rack, raft and long line methods. Hatchery production of seed by induced maturation, induced spawning and larval rearing has also been achieved. The method of harvesting, processing and the nutritional value of mussel meat are given in this paper.

INTRODUCTION

The green mussel-*Perna viridis* and the brown mussel-*Perna indica* are available along the Indian coast and Andaman and Nicobar Islands. They are sedentary animals attached to hard substrates by means of byssus. They can be transplanted from their natural habitats to any artificial hard objects in the sea. This unique character of mussels is taken advantage of culturing these animals. Mussel culture is being practiced in France since the beginning of thirteenth century. Now it has spread to other countries such as Spain, Holland, Belgium, Italy, Philippines, U.S.A, Australia and New Zealand, where different techniques are adopted depending on the hydrographic, social and economic conditions.

In terms of production and consumption, the European Union plays a dominant role with a production of 500,000 t/year. Spain is the largest producer among the EU countries with a production of 130,000 t followed by the Netherlands (80,000-100,000), Italy (70,000 t) and France (70,000 t). New Zealand produced 16,000 t in 1986, which increased to 67,000 t in 1997.

In Asia, China substantially increased the production from 100,000 t in 1983 to 400,000 t in 1995. In India the production during 2002 from capture and culture fisheries of mussels was to 15,066 t.

In India mussel culture has been introduced only very recently. In 1971, the Central Marine Fisheries Research Institute initiated culture of the brown mussel at Vizhinjam Bay. Later successful experiments were conducted at Kozhikode and Chennai in 1975 to study the possibilities of culturing mussels in the open sea. Backwater culture was started in Padanna (Kasargod district) in 1996. From a production of 20 t in 1996, the culture production increased to 1350 t in 2002 by mussel farming in the estuaries of Kerala. Karnataka and Maharashtra have also initiated mussel farming in 2002.

FISHERY

Distribution

Nearly 17 species of edible mussels are harvested or cultured world wide. The blue mussels, *Mytilus edulis* and *M. galloprovincialis*, are the most common species in Spain. *M. edulis*, black mussel *M. crasitesta* and *M. smaragdinus* are found in China, which tops in mussel production in the world. Sri Lanka, Singapore, Thailand, Philippines, Indonesia, Malaysia, Burma and Fiji have the resource of the green mussel *Perna viridis*. In New Zealand, large, green-lipped mussels, known as green shell mussel is cultured. In California *M. californianus* is cultured. The brown mussel *P. Indica* is available in Sri Lanka which is the same as that found in India. In India, the green mussel *P. viridis* and the brown mussel *P. indica* occur.

Green mussel is widely distributed along the intertidal coasts of India and found extensively around Kollam, Alappuzha, Kochi, Kozhikode, Kannur and Kasargod in Kerala and in small beds in Chilka lake, Orissa, Visakhapatnam, Kakinada, Cuddalore, Chennai, Pondicherry, Mangalore, Karwar, Goa, Ratnagiri and in Gulf of Kutch and also in Andaman and Nicobar Islands. *P. indica* has a restricted distribution and is found along the southwest coast from Varkala to Kanyakumari and on the southeast coast from Kanyakumari to Tiruchendur.

Season

Exploitation of mussels takes place during September-April along the west coast, while it is throughout the year along the east coast.

In India annual mussel production, which stood at less than 10,000 tonnes till the beginning of this decade, doubled by 2002 through increased exploitation and development of mussel farms in the coastal areas. In Kerala, traditional mussel fishery exists along the coast and mussel farming is also flourishing in the state. Among the maritime states, Kerala tops in mussel production. Along the Kerala coast, major production is from North Kerala, landed at eight major landing centres.

The estimated production during 2001-03 in different maritime states is as follows:

State	Production (tonnes)
Kerala	8934
Maharashtra	4836
Karnataka	1764
Andhra Pradesh	629
Tamil Nadu	508
Pondicherry	37

Reproduction

Mussels are unisexual. Hermaphrodites are observed very rarely. The gonad of mature female can easily be distinguished by its bright orange-red colour from that of the male, which is creamy yellow. Spawning period is prolonged extending from January to August with peak spawning during June to September. Along the east coast, spawning period is from December to July and peak during January to May.

The four main stages in the reproductive cycle are spent/resting, developing, ripe and spawning. Fertilization is external. After fertilization, it attains pediveliger stage in 15-35 days. Pediveliger attaches to the settlers (natural or artificial) with the help of byssus threads and metamorphoses to spat. In mussel culture condition index is very important. It is related to the reproductive cycle. Condition of mussel indicates the degree of fatness of a mussel or the extent to which the meat fills the cavity. This is high during non-spawning period. Another important factor is the percentage edibility. High condition index indicates greater proportion of meat in the whole weight of the mussel; those in prime condition are tasty when compared to lacid and watery meat of mussel in poor condition. The condition index is considered as high if it is above 140 and poor if it is below 70.

$$\text{Percentage edibility} = \frac{\text{Meat weight} \times 100}{\text{Total weight}}$$

When the percentage edibility is high the mussels can be harvested.

MUSSEL FARMING IN INDIA

The locations for mussel farming have been identified in Kerala, Karnataka, Maharashtra Goa, Tamil Nadu, Andhra Pradesh, Pondichery, Gujarat, Orissa and Andaman and Nicobar. The seed availability and environmental conditions play a critical role in mussel farming.

Site Selection

Open sea and estuarine areas free from strong wave action may be selected for farming. Clear sea water with high plankton production (17-40g chlorophyll/l) is ideal for mussel culture. Moderate water current (0.17-0.25m/s at flood tide and 0.25-0.35m/s at ebb tide) brings required planktonic food and carries the excessive build-up of pseudofaeces and silt away from the culture area. The water should have a salinity of 27-35 ppt and temperature of 26°C-32°C. Site selected should be free from domestic, industrial and sewage pollution. In shallow waters, sea and estuaries, rack and ren method can be adopted. For deeper regions, raft or long line method is ideal.

Open sea farming

Raft method is ideal for open calm sea conditions. Square or rectangular rafts are made with sturdy bamboo or casuarina poles. Buoyancy for the raft is provided by tying together 5 barrels of

200 liter capacity (metal oil barrel painted with anticorrosive paint or synthetic barrel). Ideal size of the raft is 5 x 5 m. The rafts are to be positioned at suitable site in the sea using anchors (grapnel, granite, concrete).

Long-line method is considered ideal for unprotected open sea conditions. Synthetic rope of 16-20mm diameter is used for the long-line (main line). The main line is supported with 220 litre barrels tied to it, spaced at 5m. The long lines and barrels are anchored in position at either ends using concrete blocks and nylon ropes.

Estuarine farming

Compared to the open sea, the estuarine ecosystems are less turbulent and shallow (<4m) and is suitable for mussel farming.

Rack method is suitable for estuaries and shallow seas. Bamboo or casuarina poles are driven into the bottom, spaced 1-2m apart in rows up on which a pandal frame is built. Seeded ropes can be suspended from those frames.

In Kerala spat settlement is found in July and August. During October the settled spat attain a length of 20-25mm and weigh 1.5-2.0g. Seeds collected from the submerged (sub tidal) areas are found to be healthier. After removing other organisms and weeds, the seeds may be washed thoroughly in seawater. About 500-750g of seed is required for seeding one-meter length nylon rope of 12-14mm or 15-20mm thickness. A 20 mm width mosquito net is used to enclose the seed on the rope. The cloth disintegrates in 2-3 days. By this time the seeds secrete byssus thread and get attached to the rope.

Food and feeding habits

Bivalves filter water for food and play a vital role in reducing suspended particles in the growing area. With the help of gills they filter water and feed on phytoplankton (diatoms) and zooplankton, grow fast and reach harvestable size in the tropical conditions sooner than in the sub tropical and temperate countries. The vertical use of water column results in the highest yield of mussel operation, upto 135 t meat per acre (from mussel story, Kathy /mussel. html).

Breeding technology

Hatchery production of mussel seed by induced maturation, induced spawning and larval rearing has been achieved by CMFRI at its laboratories in Tuticorin and Vizhinjam. The use of "GABA" for settlement of spat was successful. The commercial production of spat through hatchery is expensive compared to seed collected from the wild and no attempts have been made for commercial production of mussel seed from hatcheries. Experiments on low cost method of mussel seed production in hatchery is being tried at Kozhikode Research Centre, CMFRI in Kerala.

Harvest and utilization

Duration of mussel crop is 5-6months. Growth of mussels in the open sea farming is very rapid. An average growth of 13.5mm per month is observed in farms at different locations.

Mussels attain 80-88mm size in 5 months with an average weight of 36-40g and an average production of 10-12 kg/m.

At the time of harvest, mussel ropes are collected manually and brought to the shore and washed thoroughly using jet wash to remove grit and slit. The mussels separated from the ropes are maintained in re-circulating seawater for 24hrs and washed again in fresh seawater. This method of depuration is effective in reducing the bacterial load of the mussel meat by 90%.

Depurated mussels are then mainly sold through local market as live shell-on mussel. At present processing units take only a small quantity of cultured mussel. New strategies need to be developed to fully exploit the domestic market.

Meat from depurated mussel can be shucked in fresh condition or after boiling or steaming. Further processing of the mussel meat can be done after blanching in 5% salt solution for 5 minutes (Fig.1)

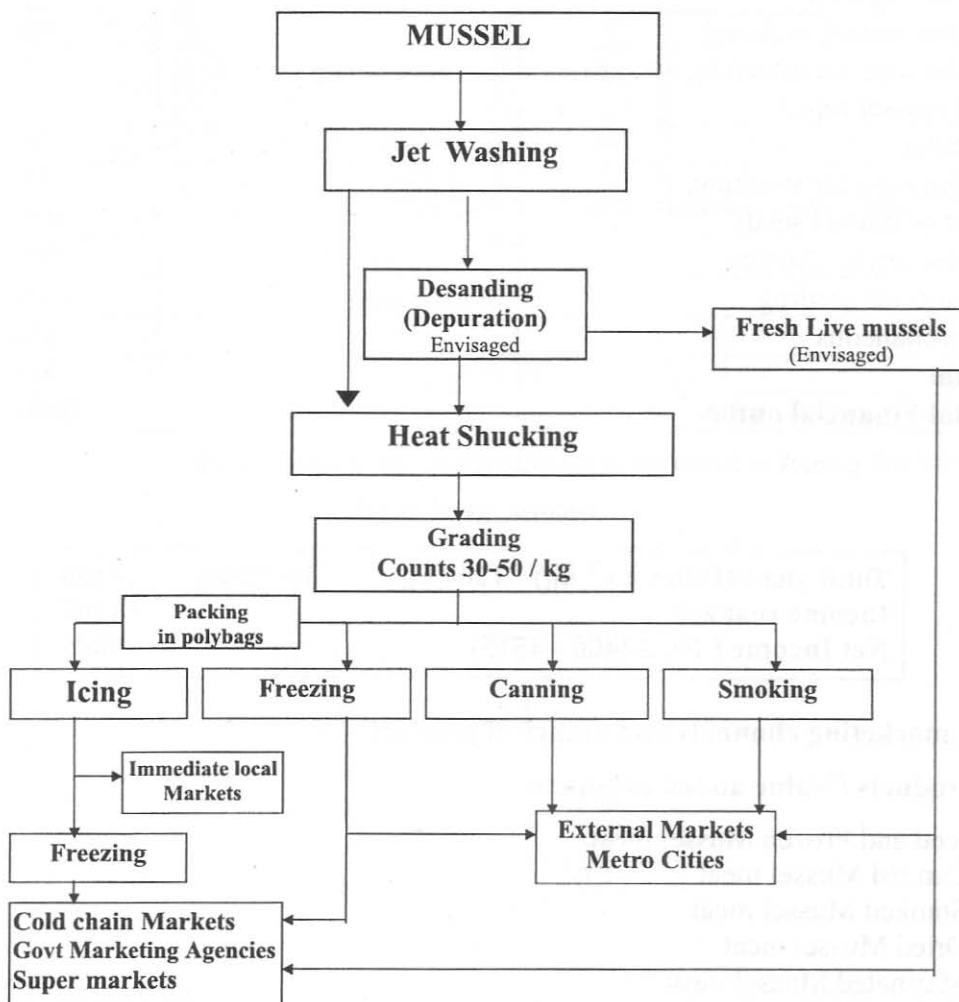


Fig. 1 Mussel harvest procedures/processing

Economics of farming

Mussel Farming by Rack culture in an Estuary

Area of Rack	5X5m (0.0025ha.)
No. of seeded ropes	100 nos
Length of seeding in each rope	1m
Culture period	6-7 months (Nov.-May)

Expenditure

Item	Quantity	Rate (Rs)	Amount(Rs)
Capital cost			
Bamboo poles	16nos	125	2000
Rope for rack construction	0.5 kg	110	55
Seeding rope	13 kg	110	1430
Total			3485
Recurring cost			
Cotton netting material	25m	12	300
Nylon rope for attaching sinkers and mussel ropes	1 kg	110	110
Needles	10 nos	2	20
Nylon rope for stitching	0.5 kg	110	55
Cost of mussel seeds	170 kg	6	1020
Canoe hiring charges	12 trips	80	960*
Labour for seeding	8 man days	150	1200*
Miscellaneous			850
Total			4515
Total Financial outlay			8000

*Rs. 1980 will go back to farmer hence actual recurring cost will be Rs .2535

Income generated

Total yield (100m x 12 kg)	1200 kg	Rs.12/kg	14400
Income realized			14400
Net Income (Rs. 14400 - 4515)			9885

Markets, marketing channels and nature of product:

Mussel products / Value added products:

1. Iced and Frozen Mussel meat
2. Canned Mussel meat
3. Smoked Mussel meat
4. Dried Mussel meat
5. Marinated Mussel meat
6. Mussel pickle
7. Mussel chutney powder

In the retail market, few mussel products are available to the consumer. The latest product is the condiment incorporated ready-to-eat fried mussel meat in vacuum packaging for domestic and export market.

Value added products of mussels like seafood cocktails are prepared and marketed by seafood export firms in India. The export of these items from India has been showing an increasing trend (Fig. 2).

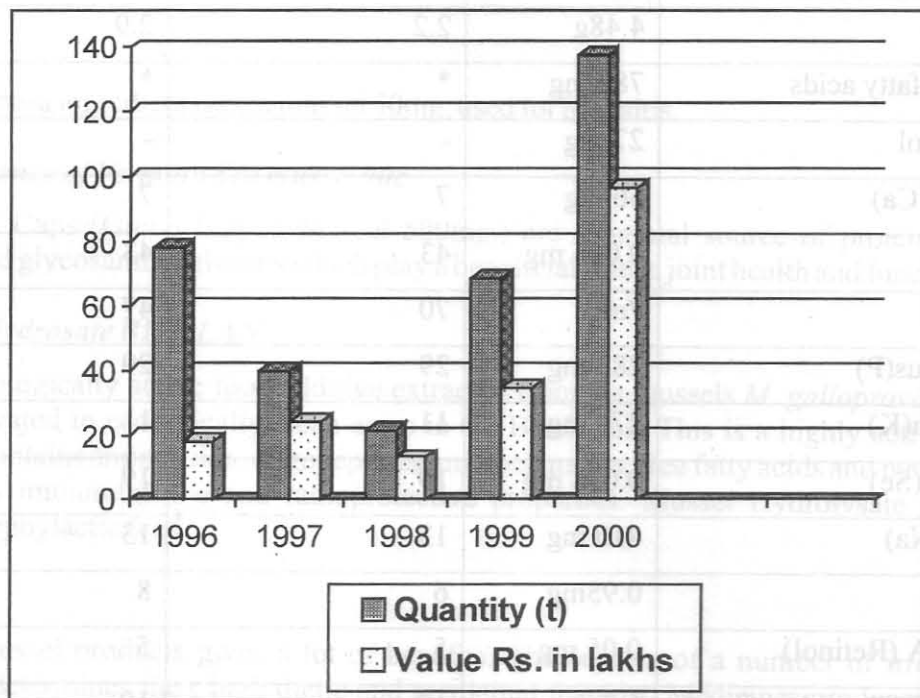


Fig. 2

Table 1. Proximate composition (%)

Moisture	82.95
Protein	8.94
Fat	1.95
Ash	1.62
Calcium	0.85
Acids insoluble	0.05
Glycogen	3.91
Phosphorus	0.33

Diversified products from mussel together with their successful marketing in overseas as well as urban markets require upgradation of technology and subsequent value addition.

Table 2. Nutritional value of 100g heat blanched mussel meat

Composition	Quantity	Adult male's (%) daily requirement	Adult female's (%) daily requirement
Energy	172 Kcal	2.9	3.8
Protein	23.8g	19	24
Oil (fat)	4.48g	2.2	2.9
Omega 3 fatty acids	782 mg	*	*
Cholesterol	27 mg	-	-
Calcium(Ca)	56 mg	7	7
Iodine(I)	0.065 mg	43	43
Iron(Fe)	7mg	70	47
Phosphorus(P)	285 mg	29	29
Potassium(K)	270 mg	11	11
Selenium(Se)	0.038 mg	19	19
Sodium(Na)	410 mg	13	13
Zinc (Zn)	0.95mg	6	8
Vitamin A (Retinol)	0.05 mg	5	5
Vitamin E (Tocopherol)	1.9 mg	19	19
Vitamin B1(Thiamine)	0.009mg	.6	0.6
Vitamin B2 (Riboflavin)	0.28 mg	16	21
Vitamin B6 (Pyridoxine)	0.19 mg	9.5	12
Vitamin B12 (Cobalamine)	0.009 mg	0.5	0.5
Niacin	1.4 mg	7	9.3
Pantothenate	< 1 mg	<20	20
Vitamin C (Ascorbic acid)	4.4 mg	7	7

* - Ratio Omega 3 to Omega 6 is 13:5

Source: United States Dept. of Agriculture Handbooks
 "Composition of Foods" No.s 8.15,1987 & 8.13,1989

Pharmaceutical Health Products

1. *Joint Complex™*

This tablet is manufactured by Health Talks, P.O. Box.961. Carmel CA.93921 (800) 3377761. One of the main components in this tablet is Green Lipped Mussel (*Perna canaliculatus*) Joint complex 250mg is designed to work within the cartilage matrix. Each nutrient in this remarkable formula is included because of its unique properties in treating specific forms of arthritis.

2. *Sinu-X*

One of the main ingredients is sea mussel 50mg, used for Sinusitis.

3. *Food Science of Vermont Sea mussel 90c*

Sea mussel Caps (Green Lipped Mussel 500mg.) are a natural source of protein, chelated minerals and glycosamino glycans which play a beneficial role in joint health and function.

4. *Mussel Hydrosate BIPOLAN*

This is a biologically active food additive extracted from the mussels *M. galloprovincialis*, *M. edulis* cultivated in ecologically clean areas in the Black Sea. This is a highly active product because it contains aminoacids, oligopeptides, microelements, free fatty acids and melanotidins. It combines immunobilitive and radioprotective properties. Mussel Hydrolysate is used in medical prophylactic feed.

5. *Others*

Intake of mussel products gives a lot of benefits. The content of a number of irreplaceable substances determines their high dietic and medicinal features. Medicines produced from the tissue of mussels have distinct immunity protection features. Natural antioxidants have been found in the lipid fraction of mussels. Mussels are rich in Omega-3 fatty acid and have more of Omega-3 than any other shellfish, which helps to prevent risk factors associated with cardiovascular and heart disease.

Zinc content of mussels has a number of health benefits. Zinc is a proven immunity booster. Optimal intake of Zinc promotes growth, mental alertness and aids in proper brain function. about 100g of mussel provides close to entire daily dietary requirement (Table 2.)

Recent research on a specific protein derived from mussels called Lyprisol is believed to have benefits in deterring from cancer.

Management measures for a sustainable production

1. Mapping and optimum carrying capacity: Though CMFRI has made initial studies on the site selection for mussel farming in Kerala, a detailed mapping of the existing and new areas in major estuaries and coastal waters with optimum carrying capacity for farming is not readily available at present.

2. Availability of seed: The seed required for culture is being collected from traditional fishing areas and this often leads to conflict between the farmers and mussel pickers. Hence it is essential that additional spat collectors be established along the coast to ensure ready supply of seed to the farmers until commercial hatchery production is established.
3. Post harvest technology: Value added products of longer shelf life need to be developed from mussel meat to increase the revenue realization from cultured mussels. Mussel fry, mussel pickle etc. are some value added products. More studies are needed to develop ethnic cuisines with longer shelf life.
4. Regulatory measures: At present there are no scientific regulatory measures or government policies for locating mussel farming areas in estuaries/nearshore areas.
5. Sewage treatment: MPEDA studies have revealed that faecal coliform content of the waterbody in the farm area is above the permissible limit. This may be due to the prevailing practice of letting the effluents without treatment.
6. Sanitary and quality control measures: At present there is no strict sanitary and quality assessment procedures for farming and product processing.

Repayment (Rs) schedule (5 years with one year grace)

Years 1	Bank loan outstanding 2	Net Income 3	Repayment Interest 4	Repayment Principal 5	Total (4+5) 6	Net Surplus (3-6) 7
1	6800	9885	816	0	816	9069
2	6800	9885	816	1700	2516	7369
3	5100	9885	612	1700	2312	7573
4	3400	9885	408	1700	2108	7777
5	1700	9885	204	1700	1904	7981

Capital cost (CC)	3485
Recurring Cost (RC)	4515
Total Financial Outlay	8000
15% Margin	1200
Bank Loan (BL)	6800
Rate of interest	12%

CONCLUSION

The fast growth rate of mussel makes it an ideal species for culture. The production can be augmented if mussel farming is taken up on a large scale. It offers scope for employment to the coastal fishers, increases foreign exchange earnings and an additional occupation for the fishing community with income potential.