

MUSSEL MEAT PRODUCTS

Mussels are sedentary bivalve molluscs found attached to submerged, hard substratum with the help of byssus thread. They are found in the inter tidal zone up to a depth of fifteen meters along the coastal area. Mussels can withstand wide variations in salinity and are found in rivers, in harbours and mouths of estuaries. They are filter feeders and feed on phytoplankton, zooplankton and detritus.

SOURCE

The green lipped mussel, *P. canaliculatus* is found only in New Zealand while the green mussel, *Perna viridis*, is found in abundance along the rocky coastal belt, in the Indo-Pacific region. The brown mussel, *Perna indica*, is found only on the Indian coast. Mussels are found all along the east and west coast and occur abundantly from Kollam to Kasargod in Kerala and southern coast of Karnataka. They are also found in Chennai, Pondicherry, Visakhapatnam, Kakinada, Ratnagiri, Gulf of Kutch, Goa, Karwar, Cuddalore, etc. The brown mussel is limited to a coastal stretch of 10 km from south Kerala coast off Kollam to Kanyakumari coast in Tamil Nadu. In the Malabar region, green mussel (*Perna viridis* - locally known as Kallumakai, Kadukka) is the major fishery.

The external colour of the shell of the green mussel is jade green to bluish green, whereas it is dark brown in brown mussel. Interior of the shell is shining in both cases. Two equal sized shells protect the internal organs. The shells are thick, equivalve, triangularly ovate in outline and hinged at the anterior end. The posterior end is almost round. The growth of the mussel is influenced by a number of environmental factors such as water quality, food availability, water current, tidal exposure and settling density. Green and brown mussels attain lengths of 80-88 mm with 35-40 g weight and 65 mm with 25-40 g in 5 months under average culture conditions. The average edible portion of the meat in cultured mussels ranges from 34.5% - 40.5%, whereas in the natural bed, the meat yield is 27-33% (CMFRI).

FISHERY

The major harvesting season spreads from September to May. Fishermen collect the mussels from the wild using a small craft from which they

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dive to collect the mussel with the help of a chisel. Mussels are also picked in intertidal areas when they are exposed due to tidal influence.

Mussel culture by advanced technologies developed by Central Marine Fisheries Research Institute. has been instrumental in increasing the production of mussels. Mussel culture is practised all along the coastal belt in estuaries and backwaters. However, cultured mussels constitute only a minor part of the total production. Open sea and estuarine areas free from strong wave action are used for farming. Different methods are rack method , raft method, long line method and horizontal culture method.

POST HARVEST TECHNOLOGY

Normally, the local population use mussels in the fresh condition for preparation of different delicacies like arikaduka (rice mussel), mussel stew, mussel fried rice and mussel biriyani. Mussel meat is exported to different countries in the frozen condition. (Table-1). It is also airlifted in the chilled condition to the gulf countries where mussel meat is in great demand.

Table -1 Export details of mussel meat

Item		2001-02	2000-01	1999-2000
Dried Mussel meat	Q (M.T.)	4	3	41
	V (Lakhs)	6.93	4.02	24.43
Frozen Mussel meat	Q	546	72	49
	V	354.96	53.06	33.17

(Source: Manne Products E. port Review 20012 002)

Different products from mussel meat have been developed over the years. The Central Institute of Fisheries Technology has successfully developed the technology/process for the preparation of dried and smoked mussel meat, marinated mussel meat, mussel meat pickle, mussel meat chutney powder, canned mussel meat and ready-to-serve fried mussel meat . However, it is seen that very few mussel meat products are readily available to the consumer at the retail market. The latest in the line is the thermal processed ready-to-eat mussel in retort pouches for the domestic and export market.

The mussel shells are composed of calcium carbonate. The shells can be commercially exploited to make lime.

NUTRITIONAL QUALITY OF MUSSEL MEAT

The proximate composition of mussel meat is given in Table 2. The mussel meat is highly nutritious and contains a number of minerals and vitamins. Tables 3 and 4 give an account of the different minerals and vitamins present in mussels . The levels of certain minerals mentioned are well below any toxic limit. Mussels are consumed by people of all strata of life. In most of the developed countries, mussels form a delicacy. It is usually consumed in the raw condition in combination with a sauce for seasoning or in the blanched (partially cooked) condition.

Table 2. Proximate composition and mineral content of mussel meat

Moisture	80.00%
Protein	13.00%
Fat	1.50%
Glycogen	3.50%
Minerals	1.50%

Table 3. Mineral content of mussel meat

Sodium (mg/100 g)	11-140
Potassium (mg/100 g)	121-480
Calcium (mg/100 g)	71-164
Phosphorous (mg/100 g)	102-170
Copper (ppm)	0.2-3.6
Iron (ppm)	10.0-127.0
Zinc (ppm)	20.0-44.8
Iodine(ppm)	0.8 - 1.9
Manganese(ppm)	0.2-3.2
Mercury(ppm)	1.5
Lead(ppm)	0.1-2.4
Arsenic(ppm)	1.7-63.0
Cadmium (ppm)	0.2-1.9
Cobalt(ppm)	0.1

(Source: Wheaton & Lawson 1985)

Table 4: Vitamin content of mussel meat

Vitamin A (I.U/100g)	33-2118
Vitamin E (mg/100g)	0.4-0.6
Ascorbic acid (mg/100g)	1.1-9.0
Riboflavin(μ g/tOOg)	120-180
Niacin(mg/100g)	1.2-2
Pyridoxine (μ g/100g)	6-190
Folic acid(μ g/100g)	41.8
B12(μ g/100g)	10.2

(Source: Wheaton ft Lawson 1985)

Bivalve shellfishes feed by filtering large quantities of water and extracting the food particles. If the shellfishes are growing in polluted areas, this type of feeding will collect and may even concentrate pathogens in their digestive system. By eating whole, partially cooked or raw contaminated shellfish, viable pathogens can be passed on to the consumer. The bacterial profiles of the bivalves are greatly influenced by the quality of the water around the natural beds. If the water is polluted, the condition will be reflected in the quality of the meat. Microorganisms like Coliforms, including *Escherichia coli*, and faecal *Streptococci* are indicators of faecal pollution. The presence of these types of bacteria in the meat is an indication that pathogenic bacteria like Salmonella, Vibrio etc. also might be present. Therefore, the microbiological quality of the bivalve meat often becomes one of great public health significance. However, studies have shown that the bacterial load of mussel meat is much lower than that of clams.

Mussels and oysters are sometimes eaten raw or lightly cooked. Inshore waters are subject to pollution by sewage to varying degrees, and some microscopic algae on which they feed may produce toxins. Consequently, as is the case with all bivalve molluscs and some other shellfish, consumption of bivalves contaminated with pathogenic bacteria, viruses or algal toxins is a significant cause of food poisoning. Therefore, harvesting, cleansing, handling and heat treatment are covered by specific regulations in the food safety legislation in developed countries.

As these unwanted particles are likely to be harmful to the consumer and hence it is necessary to remove the same before consumption. To ensure the safety of the meat, the live organisms have to be depurated as a preliminary processing operation.

The United States of America's shellfish sanitation program recommends that the level of coliforms per 100 ml of these waters should not exceed 14 faecal coliforms. Harvested shellfish can be moved from pathogen contaminated waters to clean waters, where they will flush out the pathogen over a period. Transplanting or relaying the shellfish to clean waters allows for natural purification or flushing. Controlled purification takes place in depuration plants in which shellfishes are held in tanks with rapid circulating water.

DISEASES/ POISONING

Mussels are said to be harmful when consumed during periods of red tide. This mainly occurs when dinoflagellates bloom, excrete and die. These algae produce a neurotoxin, which finds its way into the mussels. When human beings consume the contaminated mussel meat, they become affected by paralytic shellfish poisoning. Other poisoning syndromes due to consumption of infected shell fishes are neurotoxin shellfish poisoning, amnesic shellfish poisoning, and diarrhetic shellfish poisoning. The mortality rate among those consuming toxic shellfish is about 8.5% cases, but less than 1% in developed countries.

DEPURATION

The process of depuration consists of storing the live organisms in clear and clean seawater for a continuous period of 24 hours, whereby the intestines are flushed out. The organisms are stored in large containers or tanks, through which is ensured a circulation of fresh, filtered seawater. No feed or nutrient is given during this period. At this stage, chlorination of the seawater is not of any added advantage since the shells remain closed if there is available chlorine. The organisms, after this treatment (starvation for 24 hours), should be put in water chlorinated to a level of 5 ppm available chlorine for 2 hours to remove any further impurities. This depuration process is found to reduce the bacterial load of the meat by 90%. A commercially operated depuration

tank is given in fig. 1. In certain western countries where open sea mariculture of mussels is done, the harvested mussels are collected in large nets and kept as such in clean seawater for depuration. The mussels are then collected after 2-3 days.



Fig.I. Depuration tank

PROCESSING

A. Shucking

Bivalve molluscs have two main shells or valves which are joined together by a hinge and held shut by adductor muscles which function to open and close the valves which, when open, pump in seawater containing food. Mussels contain two adductor muscles and are known as dimyrian. When removed from the water, the adductor muscles of a bivalve become taut and pull the two shells together against the force which is exerted by a ligament in the hinge. These adductor muscles are also known as catch muscles since they contain Tropomyosin A-the catch muscle protein that apparently functions to lock actin and myosin together, so that the shell can remain closed without an expenditure of energy. Shells of fresh mussels are either tightly closed or will close when touched. If the shells are open or gaping, the mussels are dead or dying, and may well have an unpleasant smell. Unless the mussels are to be eaten raw, cooking the mussels in steam or boiling water normally helps to remove the meat.

Live Shucking

Shucking is mainly done by hand, using a knife, chisel etc. In commercial practice, the speed sacrifices quality of workmanship. The mantle may also be damaged in different places. The mussels are then commercially processed by hand, washed and packed in containers which are refrigerated, to be later frozen, canned or cooked. The organisms obtained in this manner are fresh, whole and have no loss of weight.

B. Steaming

Another commercial method is to steam the bivalves at 100° C. The depurated samples are washed in water and steamed in open vessels for 10-15 minutes. When the shells are fully open, the heating is stopped and the mussels drained of the water. The meat is then removed by mechanical means like sieving. In certain cases, the meat is removed manually because the flesh sticks to the shells. The organisms by this process get cooked. There is also 60-70% shrinkage with an accompanying weight loss. The meat is then manually removed from the shell.

C. Freezing

Mussel meat can also be removed from the shell by freezing the shellfish. The frozen cold temperature kills the mussel and thereby, the action of the muscles which hold the shells together, is lost. The shells can be easily pried open and the meat removed.

Bivalves are also shucked open by using heat and water jets, infrared rays and by chemical means using certain chemicals. These technologies are all patented and commercially used in limited scale.

The meat is removed from the now open shells, usually by hand, and the beard or byssus pulled out. Percentage yield by weight may range from about 8 per cent to as high as 20 per cent of the whole mussels. The meat is washed in clean fresh water, but they should not be kept in water for a long time as they will lose their flavour and appearance. The meat is now ready either for marketing as such, or for further processing into frozen, smoked, bottled or canned products. Each of these processes is described in detail below.

PRODUCTS

Mussel meat is mainly consumed in different forms. It is exported as a dried product and also in frozen/chilled form. Different types of products in the curried, fried and masala forms are prepared from mussel meat for day-to-day consumption. A few ready-to-eat products are also prepared. A few regional products like arikaduka (rice mussel), mussel stew, mussel fried rice and mussel biriyani are also prepared.

Dried Mussel Meat

The mussel meat is blanched in 3% boiling brine for 5 minutes and dried in the sun by spreading on a clean surface until a moisture level of 10% is reached. Tonne drier (electrically operated artificial drier) or solar drier can also be used. The dried product is packed in sealed polythene covers after cooling to room temperature. The product can be stored for 4 - 6 months. The dried mussel meat can be re-hydrated by soaking in water and used for preparation of various curries etc. Dried mussel meat packed in polythene is shown in fig. 2.

Smoked and Dried Mussel Meat

The blanched mussel meat is partially dried in the sun for about one hour (to a moisture level of 40-45%). The partially dried meat is then



Fig. 2: Dried mussel meat

hot smoked in a smoke kiln for 30 minutes. Coconut husk and sawdust can be used as fuel for smoking. The smoked mussel is again dried until the moisture level comes down to 10%. The finished product is packed in polythene covers for storage. The product can be stored for four months. The smoked mussel meat can be used for preparation of different dishes as in the case of dried mussel meat.

Frozen Mussel Meat

Both raw and cooked mussels are frozen, individually or as blocks. The blocks are either of 2 kg or 5 kg bulk packs whereas IQF are consumer packs weighing up to 500gms, 200gms etc. This is mainly for export to EEC countries. Unwrapped meats should be glazed before storage, and all types of pack should preferably be stored at - 20°C; thawed meats after eight to nine months storage will then be in excellent condition with flavour and texture equal to the fresh meat. Frozen fresh meat has a storage life of 40 weeks while raw iced meat has up to 8 days shelf life. Cooked meat, when frozen, has 15 weeks storage life.

Half Shelled Mussel

The mussels are cleaned and steamed after which only the shell is removed. The product is IQF frozen with the meat in single shell. These half shelled mussels are marketed in the chilled form. Raw half shelled mussels can also be prepared and marketed in the chilled /frozen forms. Fig. 3 gives a picture of cooked mussel in half shell.

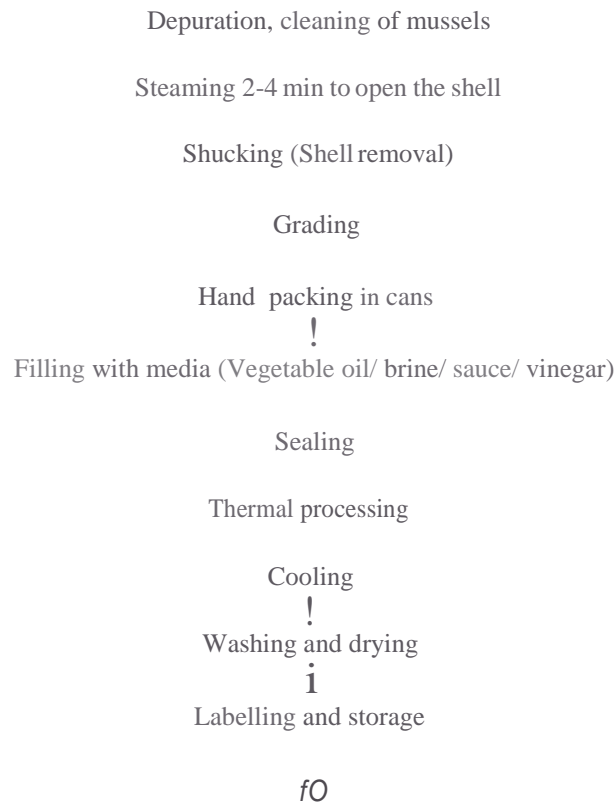


Fig. 3: Cooked mussel in half shell

Canned Mussel Meat

Mussel meat is canned in oil, brine or tomato sauce. Smoked mussel meat also is packed in refined oil. The cooked, cleaned meats are washed in fresh water or in weak brine, but not soaked, and weighed into cans; washing in weak brine prevents loss of flavour where the meats are not to be canned in brine. The method adopted for canning mussel meat is basically the same as the one employed for other canned fishery products. The medium used is either 2 % brine or refined groundnut oil. The blanched meat is packed in 8 oz. {200g} round tin containers and hot 2 % brine with 0.2 % citric acid, or refined oil. as the case may be, is added to the net weight. The cans are sterilized at 115°C for 45 minutes. Canning of mussel meat in different media is given in Flow Chart 1.

Flow Chart 1- Canning of mussel meat



Mussel Meat Marinade

The marinade can be prepared by keeping the cleaned, washed and blanched (by boiling the meat in 3 % brine for 5 minutes) mussel meat in a bath of 3 % acetic acid and 3 % salt. The mussels can be preserved in this liquid medium for a period of four months. The cooked, cleaned, blanched meat is allowed to stand for three days in an acetic acid and salt solution. The solution may acquire a bluish tinge during this time, but this does not affect the flavour of the product. The acetic acid concentration of the finished bath should not be less than 2.5 %. The meat is then packed into glass jars and covered with spiced vinegar that has been diluted with an equal quantity of water. The jars are then sealed. The finished marinade can be stored in airtight glass bottles, preferably, out of direct sunlight. Citric acid and tartaric acid can be used as replacement for acetic acid, provided, the pH of the medium is maintained at the desired level. Flavoring can be effected by adding different spices like pepper, clove, cardamom, cinnamon etc. The different steps in preparation of mussel marinade are given in Flow Chart 2. Fig. 4 shows mussel marinade packed in glass bottles.

Flow Chart 2- Mussel Meat Marinade

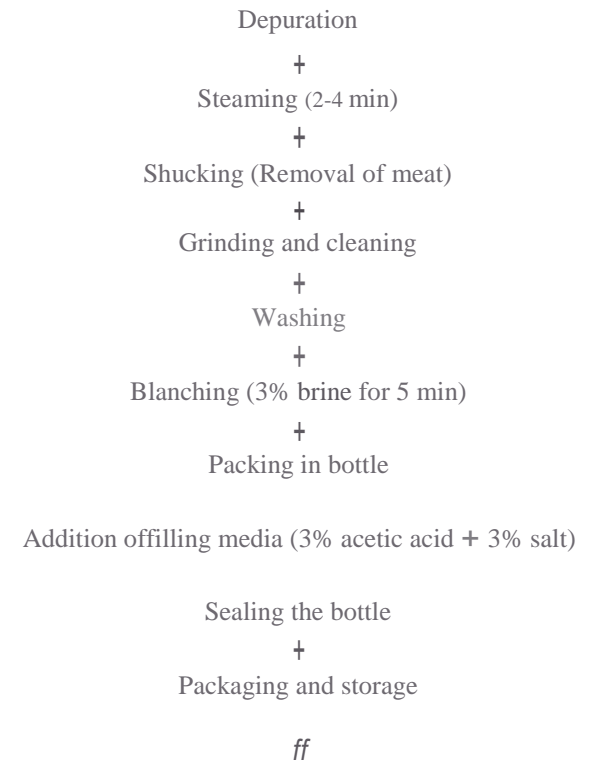




Fig. 4 : Mussel marinade

Jellied or Cooked Marinade

leaned blanched mussel meat is first pickled for three days in a vinegar solution made by adding one part of vinegar to two parts of water. The jelly is prepared by dissolving gelatin in hot water to which salt has been added. When the jelly solution gets cool, it is mixed with spiced vinegar and water. The meats are packed into jars and the mixture poured over them. Jellied mussels are not processed and should be stored in a cool place; shelf life is 2 to 4 months.

Battered and Breaded Mussel

These products offer a convenience food valued widely by the consumer. The quality of battered and breaded products depends to a great extent on the functional characteristics of the batter and bread crumbs used. There are two types of coatings-batter and crumbs. Batters are used as an adhesive in order to apply a second or subsequent coating. The two types of batters are adhesive and tempura. The products receive a coat or two each of batter followed by coating with bread crumbs, thus increasing the bulk and cost element. The pick-up of the coating can be increased by adjusting the consistency of the batter or by repeating the coating process. By convention, there should be at least 50% of fish component.

The live mussels are depurated and the meat shucked out after boiling. The meat is blanched in boiling brine, cooled, pre-dusted, battered, breaded, packed in thermofonn trays and frozen. Battered and breaded mussel meat product is given in fig. 5. The product is thawed and deep fried in oil before consumption.

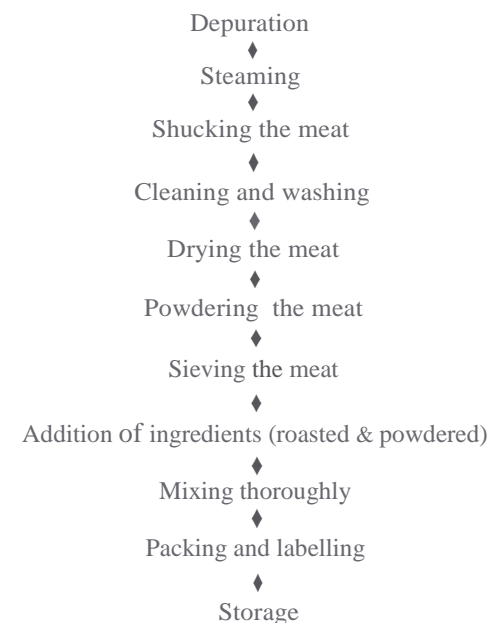


Fig. 5 : Battered and breaded mussel meat

Mussel Meat Chutney Powder

Dried mussel meat (500g), black gram dhal (SOOg), red chilly (75g), coriander(SOg), asafetida (5) and refined salt to taste are used for the preparation. The dried mussel meat is roasted in a frying pan without adding oil until it is golden brown in color. All the other ingredients are also roasted separately in the same way. The ingredients, except refined salt, are then ground to a moderately fine powder. Salt is added to taste and mixed thoroughly. The product is then allowed to cool and stored in dry, airtight glass bottles or polythene covers.

Flow chart 3- Mussel Meat Chutney Powder



Mussel Meat Pickle

Mussels of small size are usually used for the preparation of pickles (fig. 6). Bigger ones are cut into two. Ingredients are:

Mussel meat (blanched and cleaned) - 1 kg,

- Green chilly - 25g
- Ginger - 50g
- Garlic - 100g
- Red chilly powder - 50g
- Turmeric - 5g
- Mustard - 25g
- Curry leaves - 10g
- Salt
- Gingelly oil - 300ml
- Vinegar (1.5% acetic acid).



Fig. 6: Mussel meat pickle

The mussels are fried in gingelly

oil till golden brown in color and kept aside. Garlic, ginger, green chilly and curry leaves (cut into small pieces) are fried in the oil, drained and also kept aside. Red chilly powder, turmeric powder and ground mustard are warmed in the same frying pan. All these ingredients are then mixed thoroughly and allowed to cool. When cold, add refined salt (to taste) and vinegar, again mix thoroughly and set aside for two days for maturation. Then pack into dry bottles. Care must be taken to see that air bubbles are excluded. Add a thin layer of warmed gingelly oil above the pickle and secure with an airtight stopper.

Condiment-incorporated Fried Mussel Meat

This is a very tasty convenience product. It keeps well for a reasonably long duration while retaining the taste and texture. Two permitted food



Fig. 7 : Vacuum packed fried mussel

preservatives are used for its preparation. Air and vacuum packing are possible; vacuum packing provides better storage life. The method for preparation is as follows:

Mussel meat (1kg) is fried to a golden brown color. Condiments like chilly powder (30g), turmeric powder (5g), salt (20g), pepper powder (5g), and the

preservatives, Calcium propionate (3g) and Sorbic acid (2g), are added in the permitted level. The condiments are warmed in a frying pan over a low flame. The mussel meat, which has already been fried and set aside, is added to the warmed condiment mixture and thoroughly mixed. It is then allowed to cool and packed in polythene covers. The product keeps good for three months. This product is easy to prepare, has a good shelflife, can be stored at room temperature and is very convenient for use. Moreover, the product does not require any sophisticated method or machinery. The fried mussel meat (fig.7) can also be vacuum packed, 100 g each, in 12 μ , plain polyester laminated with 118 μ LD-HD co-extruded pouches (size: 12 cm x 15 cm) The vacuum packed fried product keeps well for 9 months.

Ready-to-eat Fried Mussel in Retort Pouches

The shell-on mussels are washed thoroughly in potable water chlorinated to a level of 2 ppm. They are heated in a steam chamber and the meat shucked out. The mussel meat is cleaned by removing the intestinal cavity and washed. The meat is then mixed with chilly powder (3%), pepper powder (2%), turmeric powder (0.25%) and 2% salt. It is then fried using refined sunflower oil in an electric fryer for 2-3 minutes. The temperature for frying is maintained between 170°-180° C. The material is cooled and kept aside. The fried meat is then vacuum packed in indigenously manufactured retortable pouches having a three layer configuration of 12.5 μ polyester / 12.5 μ aluminum foil / 80 μ , cast polypropylene of size 18 cm x 11cm. This product is then thermal processed in an over pressure autoclave. The product (fig. 8) can be stored at room temperature and has a shelf life of one year.



Fig. 8: Ready-to-eat fried mussel

Ari k a duka • A traditional mussel product

This is a traditional mussel preparation of north Malabar. For the preparation, fresh mussels are used. The two mussel shells are opened with the help of a knife. Parboiled rice, onions, cumin seeds, grated coconut and salt are ground to a paste with little water. This is then stuffed inside the shell and the mussel with shell steamed to allow the meat to separate out. The mussel meat containing rice is then dipped in a batter containing chilly powder and turmeric and deep fried in oil. In certain cases, the mussel is not removed from the shell. It is fried directly after stuffing with rice. During consumption, the shell is removed.

CONCLUSION

The meat of mussel is highly nutritious and has great demand in the internal as well as the export market. The local population of the Malabar Coast in Kerala prepares a number of delicacies. CIFT has standardised a number of local recipes which can be popularized in other areas through proper preservation and packaging techniques. Other value added ready-to-eat products like condiment incorporated vacuum packed fried mussel, mussel meat curry in different forms, like masala curry, chilly mussels, coconut mussel curry, battered and breaded mussel, mussel biriyani, mussel fried rice and fried mussel in retort pouches developed by CIFT can also be promoted considering the ease of preparation, long shelf life at room temperature and convenience in use.