



Design and Fabrication of a Modified Model of Indigenous Meat-shell Separator Machine for Small-scale Clam Processing Units

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Abstract

Black clam (*Villorita cyprinoides*) (Gray, 1825) is a bivalve mollusc and majority of its fishery is contributed by Vembanad lake of Kerala. Edible meat has to be separated from calcareous shells of black clam after cooking and the separation of meat from shells is a very difficult task for clam processors. Traditionally, black clam processors rely on indigenous methods for meat-shell separation using devices that lack a standard design, and do not follow any steps to assure the quality of the produce. No food quality standard parameters are adopted while considering the materials used for fabrication resulting in unhygienic handling and processing of clam meat. As a result of the unhygienic handling and processing, the product is often of an inferior quality. In this context, a modified model of indigenous meat-shell separator machine to handle bulk quantities of clams was designed and fabricated. The improved model has continuous mode of operation and the trials using this model demonstrated that it can handle 300 kg clam shells per hour with a meat-shell separation efficiency of 95%. It was found to be efficient, cost-effective, ergonomic, and durable and also which conforms to the food safety regulatory requirements. This improved model has the potential to reduce the drudgery of clam processing and can encourage members of the rural communities to take up clam processing hygienically.

Keywords: Black clam, Clam processing, Design improvement, Meat-shell separator

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Introduction

Black clam (*V. cyprinoides*) fishery is a traditional and localized fishery mostly restricted to the Vembanad lake ecosystem of Kerala (Krishna & Ammini, 2017; Suja & Mohamed, 2010). Black clam is the most important clam species exploited in India (73.8%), with Vembanad lake contributing 81.7% to the fishery (CMFRI, 2017). The black clam production in Vembanad lake was estimated at 57905 t (CMFRI, 2015). Though technologies for processing of fish and shellfish are in use, techniques for harvesting and post harvesting in clam fishery is scarce. This sector is still in a dormant phase using traditional and indigenously developed methods and technologies which are labour intensive, unhygienic and time consuming. Refinement and up-gradation of indigenously developed technologies and devices can improve income and reduce drudgery of fishermen. Improved technologies and devices are functionally similar, but are energy efficient, compact and ergonomic and have reliable parts and sub-assemblies. Improvisations in processing machinery need to be undertaken by taking into consideration the food quality standards and requirements set forth by the regulatory bodies, and in a cost effective manner.

Bivalve clams with hard calcareous shells have a natural tendency to close their shells tight when exposed to external stresses which makes extraction of edible meat by opening the shell (shucking) difficult (Srikar & Mishra, 1989). Shucking is performed by giving heat shock using hot water or steam to relax the adductor muscle of animal (Cook & Ruple, 1994). One of the major steps involved in the processing of black clam is the separation of detached meat from clam shells after shucking (Gopal et al., 2014). Manual separation of meat from large quantities of shell is laborious. Hence the

fisher folk rely on indigenously developed devices for the purpose (Suja & Mohamed, 2010). These indigenous devices lack standard design and ergonomics and no food quality standard parameters are adopted while considering the materials used for fabrication. Ergonomics and safety is very important especially for the use of women workers (Singh et al., 2015). Ergonomics is the applied science involving the design of a machine in relation to the health, safety and comfort of the operator as affected by his/her work conditions like body posture (Khan, 2015). In this regard a modified model of an indigenous meat-shell separator machine, which is user-friendly and affordable for low income fishermen groups and small scale processors to handle bulk quantities of clams, was designed. This machine also conforms to the food quality standards requirements laid down by regulatory authorities. This can also be up-scaled and adapted for bigger industrial units.

Materials and Methods

Based on the survey conducted at Perumbalam village and adjoining areas around Vembanad lake of Alappuzha district, Kerala, three major types of indigenous devices were identified which were commonly used for meat-shell separation of black clams. The most common and widely used is a hanging sieve consisting of a rectangular wooden frame with iron mesh (Type 1). The frame is hung using coir ropes, and oscillatory movement applied over the frame for a period of time separates the meat from the clam shell. The meat is then sieved to a plastic sheet placed beneath the frame (Fig. 1). This device operates batch-wise and can handle

quantities ranging from 2-3 kg per batch. After separation of each batch, the device needs to be emptied for further operations. When the quantity required to be handled is less, circular shaped, hand operated, small basket type sieve (Type II) is used, mostly by individual households (Fig. 2). Another model consisted of horizontally fixed large cylindrical drum made of iron with plastic mesh (Type III) and the rotational motion of the drum separates the meat from shell (Fig. 3) in continuous mode of operation. Each type has its own merits and demerits (Table 2) and Type III indigenous model was considered for designing the machine.

The design drawing of the machine was prepared using AutoCAD® (Fig. 4) and the meat-shell separator machine was fabricated at the Engineering work shop of ICAR-CIFT (Fig. 5). All the parts of the machine that comes in contact with meat were fabricated using food grade steel (SS 304) and the supporting stand was made of mild steel. The details of materials used for the fabrication of machine are listed in Table 1.

Results and Discussion

For designing the machine, Type III indigenous model was considered owing to the fact that it can handle bulk quantities and was suitable for continuous operation. The design philosophy followed was to use the rotating meshed drum surface to achieve sufficient impact force that can break and separate the hinge of clam shells and thereby detach the meat which gets adhered at the hinge after the shucking process. The meshes arranged around the circumference of a hollow drum, while rotation, allow the

Table 1. List of materials used for the fabrication of meat-shell separator

Sl. No.	Item Description	Specification	Quantity
1	Square tube (SS 304)	25 mm	7 m
2	Shaft (SS 304)	25 mm	2.5 m
3	Rod (SS 304)	20 mm	4 m
4	Flat (SS 304)	25 mm × 6 mm	12 m
5	Welded mesh (SS 304)	15 mm and 20 mm (mesh size)	30 sq. feet
6	Sheet (SS 304)	8 feet × 4 feet	2 no.s
7	Angle (MS)	40 mm × 6 mm	6 m
8	Bearing (MS)	25 mm	2 no.s
9	Bolt and nut (SS)	10 mm × 50 mm	4 no.s

meat to sieve down to the collection tray. Simultaneously the rotating drum moves the separated clam shells to release it through the opposite end.

The fabricated meat-shell separator (Fig. 5) constitutes an inclined feeder bin for feeding the shucked clam shells into the cylindrical drum at an angle of 30° . The drum, which is the main portion of the machine, is rotated in anti-clock wise direction using a shaft assembly. Overall length of the cylindrical drum is 1.84 m with a diameter of 50 cm. The shaft along with drum was horizontally mounted on a stand at an inclination of 10° from feeding end to the opposite end. This facilitates slow tumbling movement of shells inside the drum while in rotation. There is a semi-circular guard surrounding the drum towards the feeding end to prevent spilling of clams while feeding. The rotation of the shaft can be facilitated manually using a detachable hand lever fixed at the opposite end of feeder or by



Fig. 1. Type I indigenous device for clam meat-shell separation

using a geared motor connected to shaft using a belt assembly. The speed of rotation of the drum can be varied depending on the size of clams. The length of harvested clams varied from 11-41 mm (Kripa & Mathew, 1993) and 14-30 mm (Ravindran et al., 2006) during various months of the year. Based on this, circular mesh of 20 mm diameter was chosen for clams of size 25 mm and above, and 15 mm mesh was chosen for smaller sized clams. The separated meat is collected on a sloping tray attached below the drum. A perforated PVC pipe with water jet, attached at the top of sloping tray, directs the separated meat toward the collection bins. The empty shells are directed to the shell collection bins kept at the rear end of cylindrical drum by the tumbling motion. A semi-cylindrical guard is attached around the drum to prevent the meat from falling to the sides of the drum while in rotation.

The clam shells, after shucking using steam in a cooking chamber, were fed to the fabricated machine. The speed of rotation of the drum varied from 30 rpm to 60 rpm depending on the size of clams. For clams above 25 mm size, 40 rpm speed of rotation was found suitable for operation and the average time taken to separate meat from 10 kg of shucked clam shells was found to be 2 min. For clams below 25 mm size, 50 rpm speed of rotation was found suitable for operation and the average time taken to separate meat from 10 kg of shucked clam shells was 2 min (Table 3), which gives an indication about the capacity of the machine. The average feeding capacity of the machine can be arrived at 300 kg clam shells per hour. At 40 rpm and 50 rpm the meat-shell separation efficiency was



Fig. 2. Type II indigenous device for meat-shell separation



Fig. 3. Type III indigenous device for meat-shell separation

found to be more than 95% with very few broken shell fragments were found mixing with the separated clam meat (Table 3). At slower rotational speeds, the presence of broken shell fragments was more, probably due to the increased contact time of shells with the metal mesh. The developed machine is ergonomically designed and has a provision for mechanical operation if a motor-belt assembly is attached to the main shaft. The machine can be operated by two persons in manual mode – one for feeding the clam shells, and the other for rotating the drum using hand lever. The feeding bin facilitates for easier and continuous loading of shells into the drum. It can be operated by a single person with a motor-belt mechanism attached to the shaft for rotation and can be operated continuously for several hours with minimum physical effort.

The total cost of the meat-shell separator machine was arrived at after considering the cost of all the components of the machine (Table 4) and was Rs. 37600 for the manually operated model and Rs. 41600 for the model with motor attachment. The machine cost comprised the cost of materials for the component parts, the cost of its fabrication and other items necessary to make the components and it was found affordable for low income fishermen groups and small-scale industries. The machine parts are locally available, can be easily assembled and/or disassembled, which facilitates its transportation. The machine can be acquired, used, maintained and patronized by a group of fishermen who would be able to easily bear the cost of the machine as well as the cost of its operation and maintenance. Moreover, the machine with running approximate customisation is suitable for processing alternative species of clams available in the adjacent water bodies, which further increase the significance of this machine.

This improved model has the potential to meet the dire need of the clam processors to have an efficient, cost-effective, ergonomic, durable and easily operated meat-shell separator machine which also conforms to the food safety regulatory requirements. The fabricated machine has continuous mode of operation and the trials using this model demonstrated that it can handle 300 kg clam shells per hour with meat-shell separation efficiency more than 95%. It is suitable for small scale processors to boost productivity and enhance quality of processed clam meat. This improved model of meat-shell

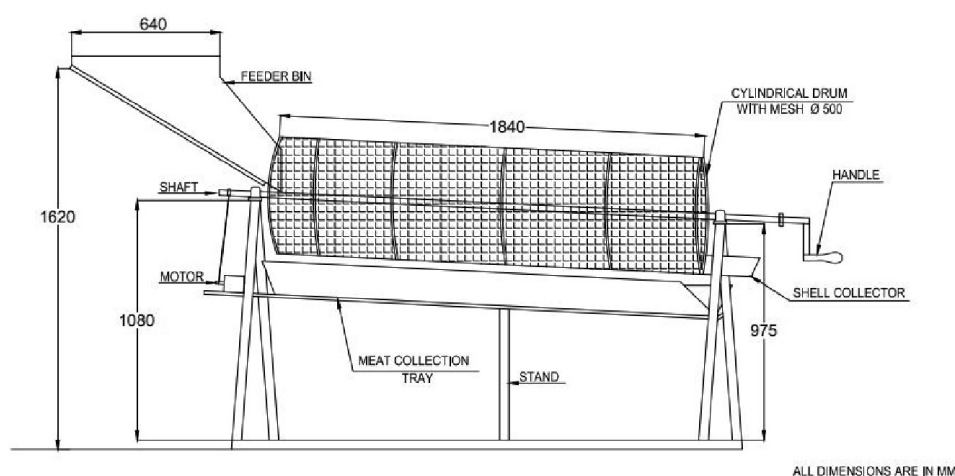


Fig. 4. Design of meat-shell separator

Table 2. Types of indigenous devices used for meat-shell separation around Vembanad lake

Types of indigenous devices	Advantages	Disadvantages
Type I – Hanging sieving tray	• Meat-shell separation efficiency is more • Cheaper • Can be constructed with locally available materials • Energy efficient	• Suitable for batch operations only • Slow operation • Lack of food grade materials for construction • Unhygienic handling of meat
Type II – Hand operated sieving basket	• Cheapest • Can be fabricated in households • Energy efficient • Ease of operation	• Suitable for small quantity shells – mostly for house hold purpose • Very slow process
Type III – Horizontal rotary operated cylinder	• Suitable for continuous operation • Can handle bulk quantities • Faster operation • Can be constructed with locally available materials	• Lack of food grade materials for construction • Unhygienic handling of meat • Chances of hazard with rusted and fragmented metal pieces

Table 3. Operational efficiency of meat-shell separator machine

Size of clam (mm)	Quantity of clam shells (kg)	Rotation speed of drum (rpm)	Time of meat separation (min)	Efficiency of meat separation (%)	Presence of broken shell fragments in separated meat
≥25	10	30	2.5	95	More
≥25	10	40	2	99	Less
≥25	10	50	1.5	85	Less
≥25	10	60	1	75	Nil
<25	10	30	3	95	More
<25	10	40	2.5	95	More
<25	10	50	2	98	Less
<25	10	60	1.5	80	Nil

Table 4. Cost of fabricated meat-shell separator machine

Item	Model for manual operation (in Rs.)	Model with motor-belt assembly (in Rs.)
Material cost (excluding mesh)	18000	18000
SS 304 mesh	7600	7600
Labour charges	12000	12000
Motor assembly	-	4000
Total	37600	41600



Fig. 5. Fabricated meat-shell separator for clams

separator will reduce the drudgery experienced in clam processing. Mechanical processing of the clam shells will also encourage engagement of many members of the rural communities of adjacent regions in processing of clams which will automatically improve their economy.

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