Development of an Alternative Technology Package for Processing Sea Cucumber

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ABSTRACT

A hygienic and profitable way of processing sea cucumber was developed for village-level application. The developed technology package involved the design and fabrication of a preparation table, a boiling apparatus, a cleaning/scraping machine and a dryer. Each of the developed machine/equipment were based from the results of the survey conducted regarding the existing processing activities in different areas of the country. The system was designed to process 100 kilos of fresh sea cucumber in a single batch. As compared to the traditional processing method, the product produced was of better quality resulting to a much higher selling price for the farmers. The developed technology complies with the processing standards set by the Bureau of Agriculture and Fisheries Standards (BAFS) (2013). The use of corals or steel brushes in cleaning was eliminated and smoke contamination was avoided. The quality was maintained since there were no smoke odor, decay and scorch marks in the product. Using the developed technology was profitable with a computed Net Present Value (NPV) of P234,000.00, a benefit-cost ratio (BCR) of 1.07 and an internal rate of return (IRR) of 19.2%. With a total capital investment of PhP234,000.00 and an annual operating cost of P192,000.00 (four months processing time in a year), farmers can realize a net income of PhP246,400.00. The developed technology was simple to operate and can be easily fabricated even in small fabrication shops.

Keywords: sea cucumber, “trepang”, processing technology package, hybrid dryer

INTRODUCTION

Holothurians, commonly known as sea cucumbers, have been harvested for over 1,000 years in the Indo-Pacific regions to supply markets in Asia for *beche-de-mer* or *trepang* (the dried form of sea cucumber). The demand for *trepang* has been growing, especially with the re-entry of China in the world market during the 1980s. Its global market is controlled by Chinese traders where the three main markets are Hong Kong, Singapore, and Taiwan. These countries are also major re-exporters of *trepang.* The industry presently suffers from overfishing and depletion of sea cucumbers worldwide due to inadequate management (Conand 2004). In the Philippines, this trend is supported by interviews with fishermen and middlemen by Gamboa et al. (2004) where frequency of fishing and catch volume are declining, more time is needed to accumulate sufficient volume for marketing, and traders no longer discriminate between species (purchasing even those with low value).

About 50 species are exploited globally, with 99% of the volume in dried or salted form. Global trade in 2007 reached more than 5,700 metric tons and was valued at US$ 55.8 million. Being ranked 6th in 2001 production wise, the Philippines is a major global exporter of trepang with 791 tons dry weight corresponding to 7.4% of global production (Conand, 2004). About 25 species are commercially valuable, out of a total of 100 known species nationwide. Based on FAO statistics in the early 2000's, the Philippines was second only to Indonesia in terms of volume of sea cucumber harvested. During the period of 2000-2005, these two countries produced on average 47% of the global volume of landed sea cucumber (Choo 2008). In 2007, the *trepang* export industry produced more than 1,100 metric tons worth US$6 million (Perez and Brown 2010). However, figures presented by Gamboa et al. (2004) and Conand (2004) showed that Philippine production has been on a decreasing trend since the mid-1980's and 1990's, respectively. Value of processed product, on the other hand, is generally increasing, reflecting continuing demand and exerting pressure on depleted populations in the wild. Data gathered from the Philippine Department of Trade and Industry showed that for the period of 2005-2008, the value of processed *beche-de-mer* (dried, salted, or in brine) imported by Hong Kong from the Philippines had a range of US$4.9-8.3 million per year (Ganchero, 2010). The latest production volume data obtained from the Philippine Statistics Authority in 2016 showed that there was a resurgence in the volume of dried sea cucumber being processed and exported from 94 metric tons in 2013 to 164 metric tons in 2015 valued at PhP 88.12 million and PhP 179.04 million, respectively. As compared to the volume produced in 2007 with a value of 1,100 metric tons, the volume exported tremendously decreased. Furthermore, according to the Bureau of Fisheries and Aquatic Resources (BFAR) in 2013 (year of the release of data), production began to decline to only 1,000 metric tons (MT) annually in the 1990s from more than 4,000 MT in the 1970s to 1980s because of overexploitation. Production is now below 1,000 MT annually, mostly undersized and low value species. Because of this, BFAR has tightened regulations for trading sea cucumber to prevent over exploitation and encourage spawning of the species. It issued Administrative Circular No. 248 specifying the permits required for sea cucumber trade as well as the permissible size for trading and transport. The circular stated that only registered fisherfolk holding an Aquatic Wildlife Collector's Permit (AWCP) by the BFAR Provincial Fishery Office (PFO) might gather sea cucumbers for commercial trade and that sea cucumbers could not be transported without a Local Transport Permit (LTP) issued by the Provincial Fishery Office or a fisheries quarantine officer. It also prohibited the selling and transport of undersized sea cucumbers – those that are only five centimeters in length – except in dried form.

Aside from declining catch volume, postharvest quality of Philippine *trepang* is also generally low due to poor processing and handling practices (Meñez, 2010). Philippine products command the lowest prices in the international market due to consistently poor quality. Data on export volume and value with respect to the global market show that the value index of Philippine products is much less than 1, which indicates that Philippine exports are either low-value species or have poor quality (Choo, 2008b). Based from standards set by the Bureau of Agriculture and Fisheries Standards (2013), dried sea cucumber are evaluated or classified according to species, size, shape, moisture content, appearance, odor, and cleanliness. Common postharvest problems observed that were validated in surveys conducted by the project team in 2012 and 2013 in different sea cucumber producing areas, included high moisture content, unreliable quality, inappropriate packaging, and poor hygiene and sanitation, which influenced the design process of the technology. A variety of methods are used in processing sea cucumber into *trepang*. These methods involved multiple handling, smoking or drying over open coals, and sun drying (Bassig et al., 2010). In other countries, the same processing method is employed. In Fiji for example, Ram et. al. (2016) reported that *beche-de-mer* (BDM) processing entails an uncomplicated sequence of actions resulting to a product that is non-perishable if stored in dry, dark conditions. This processing method currently used in the Fiji Islands was developed in the 1800s and has changed little since. Post-harvest steps include: first boiling, slitting and gutting, second boiling, smoking and finally sun-drying (Ram et al., 2014a; Purcell, 2014a). Each step in this process contributes to the resulting quality of the final product which determines the suitability of processed products for Asian markets (SPC, 1994; Sachithananthan et al., 1985; Purcell, 2014b; Conand, 1990) and their value (Ram et al., 2014b). Although these steps are uncomplicated, it requires continuous attention to obtain a high quality dry product of consistent quality. Failure to do so can result in reduced quality and value of the final product (SPC, 1994; Sachithananthan et al., 1985). Nevertheless, because of a general lack of equipment required to optimize BDM quality (e.g. kerosene burners, smoking sheds and drying amenities), BDM production in Fiji uses simple customary methods described above (Seeto, 1999; SPC, 1994; Ram et al., 2014a).

The use of proper and timely drying methods can significantly improve quality of *trepang*. Mechanical dryers using convection methods and heated by burning biomass represent the best option for small-scale processing. Tanikawa, et. al. (1985) reported that for boiled sea cucumber, the maximum drying temperature should not exceed 70 ^{o}C. For large-scale processors, state-of-the-art freeze dryers are used commercially to produce dried products of the finest quality. However, freeze drying is recognized as the most costly drying method (Ratti 2001). It is therefore imperative to develop an appropriate processing technology for sea cucumbers. Such technology empowers farmers to command better prices for their products as well as reduce losses and minimize products being classified as rejects. This empowerment improves the income of the stakeholders on account of a generally-improved product quality which raises market values and selling prices here and abroad and compensates losses due to dwindling supply of sea cucumbers.

OBJECTIVES

The general objective of the study was to develop an appropriate processing technology to improve the quality of sea cucumber being processed by both farmers and consolidators.

Specifically, the study aimed to:

1. Evaluate the existing sea cucumber processing practices in different areas of the country;
2. Identify gaps and technology needs to improve the quality of processed products;
3. Design and fabricate a technology package for processing sea cucumber suitable for small-scale application;
4. Evaluate the performance of the developed processing machines in terms of technical efficiency and product quality; and
5. Determine the financial viability of using the developed processing technology package.

METHODOLOGY

Site visits to sea cucumber gatherers and processors were conducted in various parts of the country to assess the existing practices being employed. Interviews were done to gather basic information on the processing of sea cucumbers including the current situation of the industry. Existing technology employed were evaluated and the processed product quality was assessed. Secondary data collection was also done to gather information from previous studies. The study focused on sandfish or *Holothuria scabra* which is the only exploited tropical sea cucumber species with an established hatchery culture technology and that production is aimed towards commercial scale production through sea ranching (Menez et. al. 2016).

Based from the information gathered, a technology package for processing sea cucumber was designed and developed. Major factors considered in the development include: a) simple and low-cost technology suitable for village-level application since the target beneficiaries were the small fisherfolks, b) complies with the good manufacturing practice (GMP) which entails common sense sanitary processing activities to ensure product quality and safety, c) produce high quality products to ensure high buying prices for the dried products. This include the proper handling and processing of fresh sea cucumber and the determination of the optimum drying temperature that can be used to hasten the drying process and prevent case hardening, and d) many stakeholders will benefit from the technology which are mainly composed of small to medium-scale fisherfolks or fisherfolk cooperatives.

Laboratory and actual field testings of the fabricated machines were conducted. Cost-and-benefit analysis was carried out to compare the traditional practices and the developed processing technology. The Net Present Value (NPV), Internal Rate of Return (IRR) and the Benefit-Cost Ratio (BCR) were the indicators used to determine the viability of using the developed technology. Feedbacks on the use of the machine prototypes were gathered to further improve the developed technology.

Performance of the developed technology package was evaluated based from the quality of the processed sea cucumbers. The standards set by the Bureau of Agriculture and Fisheries Standards (PNS/BAFPS 128:2013) on the physico-chemical properties of dried sea cucumber (Table 1) were used as parameters and for evaluating if the product is defective, class B or reject. The following standards were used:

1. Presence of foreign matter defined as any matter/object present in the sample unit which is not derived from dried sea cucumber product (excluding packing material), which is readily recognized even without magnification. It may be present at a level determined by any method including magnification indicating non-compliance with good manufacturing and sanitation practices, but does not pose any threat to human health,
2. The appearance of the product should not have any of the following: i) molds; ii) salt crystals; iii) chalky deposits and extraneous matter; iv) cracks and bruises; and v) scorched or burnt surface,
3. The product should not have objectionable odor which is indicative of decomposition,
4. The product should not have deformed shape (e.g. bent, twisted, flattened), and
5. The product should not have a case hardened texture or hard outer layer but moist inner layer.

Table 1. Physico-chemical requirements of dried sea

CHARACTERISTICS	REQUIREMENT
Moisture content, % by weight, maximum	1.5
Sodium chloride, % by weight, maximum	2.5
Acid insoluble ash, % by weight, maximum	2.5
Length (cm), minimum	5

Source: PNS/BAFPS 128:2013

RESULTS AND DISCUSSION

Traditional Processing Practices

Interviews and site visits were conducted and other visits were done in coordination with ongoing activities of the Department of Agriculture – Bureau of Agriculture & Fisheries Standards (BAFS). These sites included Calatagan, Batangas); Cebu City; Coron, Palawan; Digos, Davao del Sur; Pagbilao Quezon; Lopez Jaena, Misamis Occidental; Bongao, Tawi-Tawi; Puerto Princesa City, and Zamboanga City. Key informants in these sites were fisherfolks, traders, and exporters. Interviews with fisherfolks showed that each site has its own methods of processing sea cucumber.

The following are the common method used by fisherfolks in processing *Holothuria scabra:*

1. Collection of live sea cucumbers

Live sea cucumbers are collected by either picking in shallow waters usually during low tide, diving in deep waters with or without the use of air compressors or collecting the sea cucumber that were trapped together with other fishes in nets during fishing activities. The collected sea cucumbers are then brought to local processors who pay in cash. These are placed in large diameter basins with sea water to avoid evisceration and deformation.

Problems on the collection of sea cucumber include a) indiscriminate collection wherein even small sea cucumbers (Figure 1) are gathered and processed, disregarding the BFAR circular number 248, which specifies the permits required for sea cucumber trade as well as the permissible size for trading and transport, b) dwindling catch due to previous overharvesting activities, c) BFAR's banning of the use of compressors likewise affected the catch volume.

2. De-gutting

Processing of sea cucumbers starts when sea cucumbers are de-gutted (Figure 2) to remove the entrails or internal organs. This is done by either making a 2-3 cm slit on the tip or anal area and pressing the sea cucumber hard enough for the entrails to squirt or a long incision in the sea cucumber belly for easier cleaning.

3. Boiling

After de-gutting, the sea cucumbers are cooked by placing them in a large cooking vat ("kawa") (Figure 3), filled with tap water which is sufficient enough to submerge the sea cucumbers. Boiling is done to soften the spicule layers for easy removal as well as to toughen the sea cucumber. Cleaning is done when the texture is rubbery, that is around 10-15 minutes after the water has boiled.

4. Cleaning

The calcareous spicules or substances adhering on the surface of the sea cucumbers are removed in the process of cleaning. The

(a) (b)

Figure 1. Freshly-caught sea cucumber, (a), and inclusion of small-sized sea cucumber (b)

(a) (b)

Figure 2. De-gutting of sea cucumber (a) appearance of the dried product when a long incision is made (b)

(a) (b)

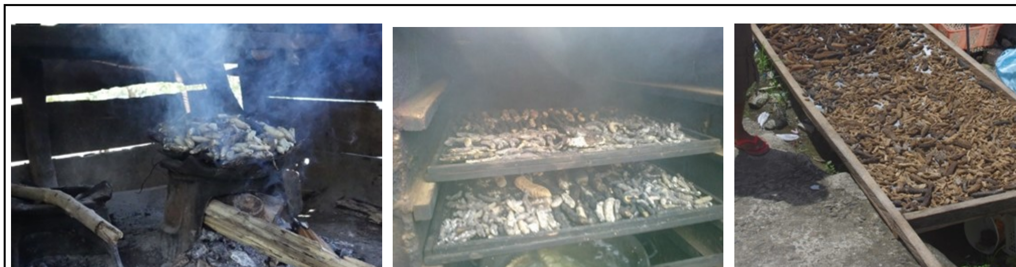
Figure 3. Cooking of the de-gutted sea cucumber in cooking vats (a), and in open flames (b)

spicule layers are very hard to remove. There are many methods employed by farmers, the simplest is to rub the sea cucumber in rough surfaces like stone or pavement (Figure 4). Other methods include the use of corals, steel wool or brush (Figure 5). Still in some areas, papaya leaves are used to soften the layers by rubbing it to the sea cucumber or burying the sea cucumber in a sand pile and then scrub the sea cucumbers using the above-mentioned tools to completely remove the spicule layers.

Figure 4. Cleaning rubbing the sea cucumber on a coarse surface

(a) (b) (c)

Figure 5. Cleaning using coral (a); some types of corals used (b); and used steel brushes (c)



(a) (b) (c)

Figure 6. Traditional method of drying: smoke drying using a makeshift local stove (a); using a local tapahan; and (b), by solar drying (c)

5. Re-boiling

The sea cucumbers are re-boiled for another 10-15 minutes or until they become tough or rubbery in texture again. This is done since they were deformed or flattened during the cleaning process. Re-boiling likewise ensures the straightness of the sea cucumber which is required by buyers., since not all processors do re-boiling.

6. Cleaning after re-boiling

After re-boiling, the sea cucumbers are again inspected for remaining spicule layers. If there are still remaining spicule layers, these are scraped using the same tools, and there is no need to re-boil afterwards since, sea cucumbers were handled for just a short period.

7. Drying

Small fishers usually produce *trepang* in a semi-dried condition (e.g. the material can be bent or squeezed by hand, but has a tough rubbery texture). Initial or primary drying is done by placing boiled sea cucumber over hot coals, a practice also known as smoking, although the primary objective is to remove the moisture of the product as quickly as possible. The simplest method of smoking employed is by placing the sea cucumbers on a piece of steel mesh and placed over hot coals (Figure 6a). In some areas, enclosed structure, similar to a *tapahan* is used which are constructed from concrete hollow block walls with several wooden trays for drying larger volumes of product (Figure 6b). The drying temperature inside these dryers can be easily controlled at around 70°C, unlike placing the product over hot coals that can reach above 70°C. Quality of dried sea cucumber produced from these enclosed dryers are much better than those placed over hot coals. Once the product is sufficiently dry, many fisherfolk do sun-drying to further reduce the moisture content (Figure 6c). Ideally, a properly dried sea cucumber feels stone-hard (i.e. it cannot be bent, squeezed, or broken by hand).

Figure 7. Salted sea cucumbers

8. Other processing methods used by sea cucumber processors

Some processors add salt (Figure 7) to the sea cucumbers prior to drying as preservation method. This is to avoid the fast deterioration of the products and avoid foul odor. However, this method is not acceptable to most buyers. Aside from the additional weight brought about by the addition of salt, buyers do re-processing to eliminate the saltiness of the sea cucumbers. As expected, the buying prize for the processed sea cucumbers with salt is down-graded.

Figure 8. Sea cucumber samples being de-gutted in the preparation table (a), the slot on the preparation table (b)

Results from both the laboratory and field testing activities conducted showed that processing live sea cucumbers weighing more than 600 grams have a product yield of 5-8% after undergoing the different processing stages until reaching dry, stone-hard condition. While a product yield of only 3-5% was obtained when live sea cucumbers weighing less than 600 grams were processed. This only showed that it is more profitable to process mature and heavier sea cucumbers.

The Developed Sea Cucumber Processing Technology Package

Based from the conducted surveys, a line of technology was developed to process sea cucumber producing high quality (class A) products that complies with good manufacturing practice. The following were the developed technologies:

1. Preparation Table

A stainless preparation table was fabricated for de-gutting and cleaning activities (Figure 8) as well as to ensure the sanitary working conditions. For easy disposal of the entrails, a slot was provided. Under the said slot a pail or any other similar container was positioned to catch the waste materials.

2. Cooking Vat

A stainless steel cooking vat (Figure 9) with cover was fabricated with a volume capacity of 50 liters. It was made of a thicker gage material for durability and the diameter was wide enough to accommodate bigger sized sea cucumbers to avoid curling.

3. Mechanical cleaner

To simulate the manual brushing and the use of coarse materials like coral, stone or pavement, a mechanical cleaner was designed and developed. The machine (Figure 10) consists of a concrete cylinder and a brush made of nylon attached to a single shaft. The machine can be powered by either an electric motor or a single cylinder engine.

Figure 9. The fabricated stainless cooking vat

4. Dryer

A dryer was designed and fabricated which was patterned to the traditional *tapahan* used by processors. It can use either biomass waste (firewood, coconut shells or husks, rice hull) or a solar collector for heating, does not require electricity to operate, and isolates the raw material from combustion gases (eliminating smoky odor). Initial tests showed that the prototype was capable of producing stone-dried product (moisture content <10%) that is well-shaped and free of smoke residue. The prototype dryer developed can be heated by solar heat or biomass stove or burner (Figure 11). This will allow fisherfolk to perform virtually non-stop drying of sea cucumber. Solar heat can be used during the day when weather conditions are favorable, while the biomass burner can be loaded continuously for all-weather drying. The hybrid dryer is composed of two sections: the heating chamber located at the bottom, and the drying chamber located on top. The heating or combustion chamber (Figure 12) serves to contain the heat of combustion produced by a rice hull stove placed inside. Other biomass stoves or burners can also be utilized as heat source. In the absence of stoves, other biomass materials like coconut husks, large twigs or branches can be directly fired into the combustion chamber. A chimney allows combustion gases to escape. The two sections are separated by a steel plate that serves as a heat exchanger and prevents smoke from entering the drying chamber. Removable trays for holding product to be dried are held in the drying chamber. Vents at the top and bottom of the drying chamber allow hot air with high moisture to escape and fresh, dry air to come in. The top panel of the drying chamber is angled and made from clear glass. On sunny days, the chamber can be used as a solar dryer to minimize cost of fuel.

Figure 10. Close-up view (a) and full view (b) of the mechanical cleaner

A simple processing shed must be constructed, similar to the one shown in Figure 13, for the safety of the operators as well as for easy movement or flow of the processing activities. This will likewise ensure the safety of the machines from rains, strong winds and other environmental factors. The processing shed can also be used as storage area for processed sea cucumbers.

Field Testing Activities

The developed sea cucumber processing technology package was field tested at the Palawan Aquaculture

Corporation (PAC), a private company with land and sea rights for aquaculture operations on Baquid Island, Coron, Palawan. It was also field tested in Morong, Bataan with the assistance of the Mabayo Fishermen's Association and in Victory Island, Bolinao, Pangasinan with the help of Victory Fishermen's Association. Live sea cucumber samples were gathered and processed based on the recommended procedure by the National Fisheries Research and Development Institute (NFRDI).

Ocular inspection of the dried product in terms of quality showed that the products are straight and well-dried. Based from the size and appearance, they can easily be classified into Class A.

Results from the field testing activity conducted in Barangay Victory, Bolinao, Pangasinan showed that the dried products using the dryer had better quality as compared to their traditional drying method. The introduced dryer was used everyday for 3 months from June to August 2014 and they were able to process around 1000 kg of fresh sea cucumber with an average of 120 kilos per week. From the processed sea cucumber, a gross income of P50,000.00 was realized per month. Some of the comments regarding the introduced dryer include: a) the dryer can accommodate much bigger volume of fresh sea cucumber, b) the dryer can be left alone requiring less manpower, c) dryer use resulted to a much better quality product, and d) members of the association want to have a unit of their own.

Technical Evaluation of the Developed Technology Package

Technical evaluations of the fabricated machines were focused only on the mechanical cleaner and the hybrid dryer since both the preparation table and cooking vat which are part of the technology package, were developed to answer the product safety and sanitary aspect of sea cucumber processing as well as to satisfy the requisite of the Good Manufacturing Practice (GMP) principle.

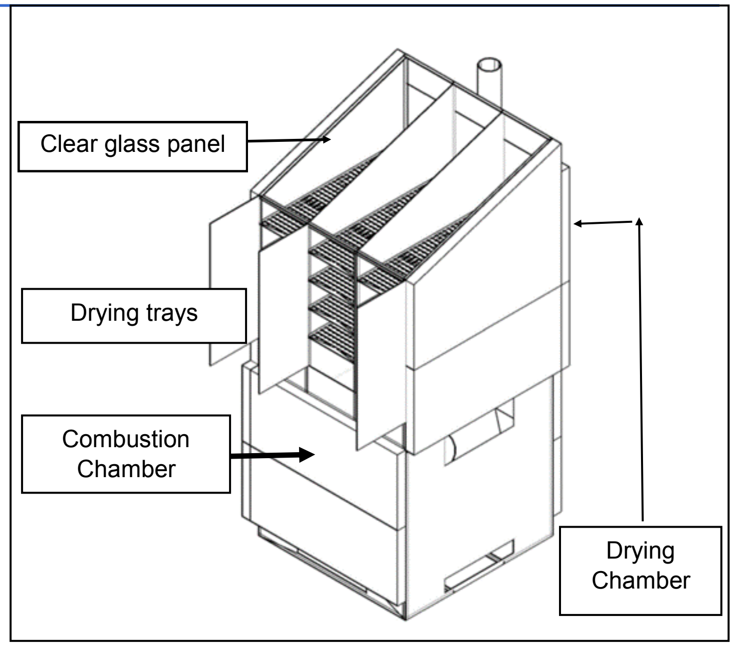


Figure 11. The developed hybrid dryer

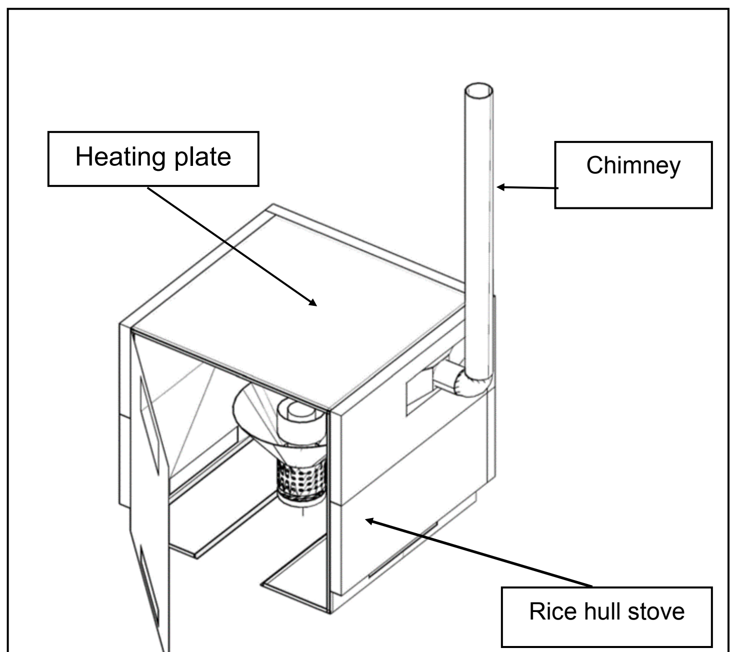


Figure 12. The combustion chamber component

Figure 13. The make-shift shed

1. Mechanical cleaner

Cleaning of boiled sea cucumber (*H. scabra)* was very hard and time consuming because the spicule layers were difficult to remove. Field testing using the mechanical cleaner showed that there was not much difference in the cleaning time when compared to manual cleaning since the machine developed was a hold-on type unit where cleaning of sea cucumber was done one at a time only. However, samples cleaned using the mechanical cleaner were much better than samples manually cleaned. Furthermore, using the machine was less tedious since the samples were just held in place and fed to the rotating mechanism by the operator akin to using a bench grinder. Unlike in manual cleaning, the samples were held in place by one of the person's hand and a brush on the other hand moving it back and forth onto the samples. In case of cleaning using a rough surface, the samples were held in one hand and rubbed on the rough surface on a reciprocating motion.

Results from the survey, showed that there were other means of removing the spicule layers. One was to rub the sea cucumber with papaya leaves. Laboratory experiments made showed that using papain (the enzyme present in papaya leaves) can indeed loosen the spicule layers. However, when the samples were dried up to stone dry conditions, samples were brittle. The effect of using papaya leaves on the final product should likewise be studied. Other processors bury the sea cucumber in the sand after boiling. The sea cucumbers were then cleaned the following day. At this time, the spicule layers were very easy to remove. The problem associated with this practice is the sanitary issue as well as deterioration that might take place. Another unsafe cleaning practice is the use of steel brush. Cleaning using steel brush is much faster than using ordinary nylon brushes, However, there is a strong possibility that steel bristles might be detached and imbed on the sea cucumbers being cleaned posing health risks.

2. Dryer

Tests on the prototype as a solar dryer with no product load showed that air temperature inside reached a maximum level of 67.9^{o}C with an average temperature of 61.3 ^{o}C. Average ambient temperature during the same period was 32.7 ^{o}C. Figure 14 illustrates the temperature and relative humidity readings inside the drying chamber in a typical sunny day. When the same test was done using the rice hull stove in the combustion chamber, the maximum temperature in the drying chamber was 71.4^{o}C. On the other hand, using firewood instead of rice hull, the maximum temperature in the drying chamber was recorded at 74^{o}C. Using biomass materials as fuel to heat the heating plate, the temperature inside the drying chamber can be maintained at the 70 ^{o}C range for safe drying by manipulating the inlet and exhaust vents and by controlling the chimney opening. Using an average drying temperature of 60^{o}C, boiled sea cucumber samples were dried using a forced circulation oven. After four (4) days, drying was complete; initial and final moisture content was 68.5% and 6.5% wb, respectively.

Since many fishers use smoking for primary drying of sea cucumber followed by intermittent sun drying, the hybrid dryer was tested in combination with sun drying, solar drying, and oven drying to simulate fishers' practice. A rice hull stove was used as the heat source. Sea cucumber samples of different species (H. scabra, 'hanginan', etc) from Calatagan, Digos, Bolinao, and Bongao were placed in the dryer for two days and brought to a semi-dried condition (MC ≈ 40%). Once semi-dry, the samples were divided into three portions, and either sun-dried, solar-dried, or oven-dried during the daytime. At night, the samples were kept at room conditions (26-28^{o}C, 70-90% RH). Using the rice hull stove, a maximum temperature of 68 ^{o}C was reached while the relative humidity was at an average of 27%. Results showed that large samples reached semi-dryness after 24 hrs of continuous drying while smaller samples tended to dry faster. Three days of intermittent drying (regardless of method) was needed to reach a stable final MC ranging from 5 to 8%. Upon reaching these moisture levels, samples felt stone-hard when tested by hand.

Post-processing quality evaluation

A visit to two consolidators in Coron was conducted to gather feedback on the quality of the dried product. These consolidators were XGF Marine Products

Trading and Oceancell Trading International Corporation. According to employees interviewed during the visit, the dried product could be considered as Class A due to the size and quality. The only defect observed in a few samples was the presence of residual spicule layer. This could be addressed by enhancing further the cleaning activity. Buying prices for Class A at that time were Php 5,300 per kg for extra-large products, and Php 4,300 for large products. Those considered as large reject product were priced at Php 1,350 per kg.

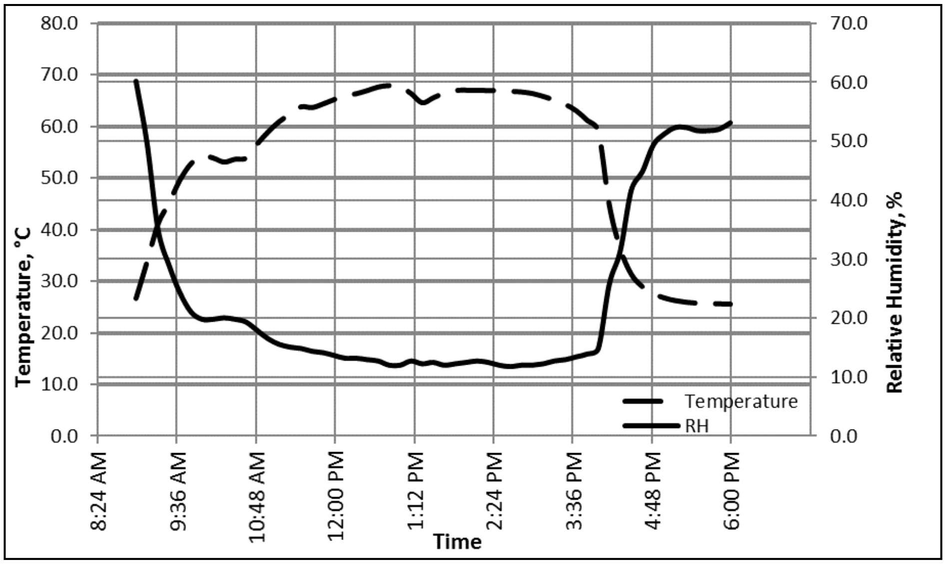


Figure 14. Temperature and RH inside the drying chamber using solar energy as heat source

Cost-Benefit Analysis

During the conduct of the actual field testing of the developed sea cucumber processing technology, it showed that good quality dried sea cucumber product can be achieved. Table 2 shows the difference in the net income if quality products will be marketed using the assumptions which are based on the results of the survey conducted by the study (Table 1).

Table 1. Assumptions in computing income difference between traditional processing and the use of the developed sea cucumber processing technology

PARAMETERS	DETAILS
Species	*Holothuria scabra*
Price (live)	PhP70/kilo
Processing time	1 week to process 100 kg fresh sea cucumber (8 kg dried)
Harvest/processing season per year:	4 months
Composition of fresh sea cucumber catch	30% Large, 35% Medium and 35% Small
Quality of dried products	From the developed processing technology – 80% Class A and 20% reject
Traditional processing method	– 20% Class A and 80% reject

Prices were based on the prevailing market price for the different sizes and quality of processed sea cucumbers (Table 3). Using the different assumptions enumerated, a considerable difference in the net income per year can be realized as compared to the traditional processing method. This clearly shows the profitability as well as the importance of improving the quality of products produced which can be easily achieved by using the developed processing machines. Using discounted measures in assessing the project worth, it showed that the use of the developed processing machines is profitable with a computed Net Present Value (NPV) of P100,264.45, a Benefit to Cost Ratio (BCR) of 1.07 and an Internal Rate of Return (IRR) of 19.2% using a discount factor of 10%. Table 4 shows the summary of the initial investment and the annual operating cost required.

SUMMARY AND CONCLUSIONS

The poor quality of products has significant impact on the selling price. Low quality products are down-graded to class B or as rejects which command lower price. Some of the product quality issues include irregularly shaped or twisted at dry stage (buyers prefer straight), scorched or burnt, bruised, excessive moisture due to case hardening, not properly cleaned and with foul or smoky odor which is common to the traditional sun-dried or smoke-dried method.

The development and application of the technology package for processing sea cucumber has been proven to increase the product quality and solved most of the problems inherent to the traditional processing methods of sea cucumbers. The developed technology was based on the processing of sandfish (*Holothuria scabra*), since, this is the only species with established hatchery culture technology and with high market value. However, the developed technology can likewise be used for other sea cucumber species.

With the stricter efforts of BFAR towards regulating the harvest and trading of sea cucumber, and the established hatchery culture technology for propagation, it is expected that sustainable harvest could be ensured for the developed technology processing application.

Table 2. Comparison in the net income between the traditional drying method and the use of the developed sea cucumber processing technology

SIZE	NET INCOME WITH NEW TECHNOLOGY (PhP)	NET INCOME WITH TRADITIONAL DRYING METHOD (PhP)	DIFFERENCE (PhP)
Large	108,864.00	40,896.00	67,968.00
Medium	82,656.00	31,584.00	51,072.00
Small	54,880.00	21,280.00	33,600.00
TOTAL	**246,400.00**	**93,760.00**	**152,640.00**

Table 3. Prevailing buying price of dried sandfish (*Holothuria scabra*) locally named "*putian*" or "*cortido*"

SIZE	PRICE/KG
Large (L)	4,300.00
Medium (M)	3,100.00
Small (S)	2,350.00
Reject Large (RL)	1,350.00
Reject Medium (RM)	1,200.00
Reject Small (RS)	1,100.00

Source: Oceancell International Trading Corporation, Coron, Palawan as of April 15, 2013

Field tests using the developed processing technology showed that it was possible to produce Class A product. Since the technology is very simple, easy to operate and maintain, the use of this technology will ensure that even small fishers with minimal training will be able to produce good quality product thereby increasing their income as a result of better prices for the finished products.

RECOMMENDATIONS

Considering the marked improvement on the quality of the finished sea cucumber products using the developed processing technology, it is recommended that a social-acceptability survey be conducted in areas were the technology was field tested to establish the need for the technology as well as the many benefits that farmers can gain

Table 4. Capital investment and annual operating cost summary

CAPITAL INVESTMENT	QUANTITY	UNIT COST (P)	TOTAL COST (P)
Processing Shed Equipment	1 unit	100,000.00	100,000.00
Preparation Table	1 unit	8,000.00	8,000.00
Cooking Vat	1 unit	6,000.00	6,000.00
Mechanical Cleaner/Scraper	1 unit	40,000.00	40,000.00
Dryer	1 unit	80,000.00	80,000.00
Total			**234,000.00**
Annual Operating Cost			
Live sea cucumber	1600 kilos	70.00	112,000.00
Labor	160 man-days	350.00	56,000.00
Transport Cost	4 trips	2000.00	8,000.00
Fuel and Utilities	4 months	4000.00	16,000.00
Total			**192,000.00**

from using the technology. Afterwards, the technology will be pilot tested in different areas where sea cucumbers are abundant. This is to show local fisherfolks and processors that there is an alternative way of processing harvested sea cucumbers instead of the traditional processing method which usually produced low-quality product due to smoke contamination, un-even drying, not properly cleaned, with foul odor and burnt or with scorched marks. Furthermore, some modifications are necessary to fine-tune the developed technology and to conduct value analysis of the technology to minimize the cost of the machines. It is likewise recommended that statistical analyses be conducted in the technical evaluation of the developed processing technology to ably support the initial findings.

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