

The Saga of Fisheries Post-harvest Technology in Southeast Asia: from *Fish Balls* to *Fish Bah Kwa*

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When the Singapore-based SEAFDEC Marine Fisheries Research Department (MFRD) became operational in 1969, it was tasked to undertake R&D on fishing ground development, fishery resources investigation, oceanography, handling and preservation of fish onboard fishing vessels at sea, and improvement of fishing equipment. After the loss of its research vessel, the M.V. Changi in April 1974, MFRD was obliged to shift its emphasis to fisheries post-harvest technology. The refocusing of its programs was timely considering that landings of trash fish in the region during that decade, had increased in view of the expansion of trawl fishing activities, and this necessitated the conduct of activities for more efficient utilization of the catch for human consumption while keeping the quality of the fish. In addition, demand for the region's traditional fish products such as dried, salted, smoked, and fermented fish had also increased, making it imperative to improve the region's traditional fish products with adequate quality control based on organized quality standards for the safety of consumers. Thus began the new fisheries post-harvest technology program of MFRD, with emphasis on fish utilization and preservation, and quality upgrading of traditional fish products. Consequently, the amended Plan of Operation and Program of Work of MFRD which was adopted by the SEAFDEC Council of Directors provided that MFRD would carry out R&D on post-harvest technology directed towards maximum utilization of available fish resources and development of fish products from under-utilized fish resources with a view to reducing wastage; addressing the problems related to handling, preservation and quality control of fish and fishery products; and transferring of the developed post-harvest technologies to the Southeast Asian region through capacity building.

After being equipped with its new mandate, the SEAFDEC Marine Fisheries Research Department (MFRD) initiated in 1978 an investigation of the various means of utilizing available fish resources, mainly small demersal fishes as trawl by-catch, also known as “trash fish”. At the start, MFRD made use of these low-market value fishes as new raw materials and improved the production of popular traditional comminuted products for human consumption, e.g. fish balls, fish cakes, especially in terms of safety and quality. Later on, these were used as raw materials for the production of surimi. With continued improvements in the technological approaches, MFRD was able to establish the methods of producing frozen surimi or fish jelly products which have been picked up by many Southeast Asian countries, leading to the dramatic growth of the surimi industry in Southeast Asia.

Surimi or frozen minced fish meat or fish paste or fish jelly has always been an integral part of the Asian cuisine, with Japan reported to have registered the highest volume of annual consumption at about 0.5 million metric tons (MT) and at the same time also one of the world's highest producers of surimi. In Southeast Asia, the key players in surimi production are Viet Nam, Thailand, Myanmar, and Malaysia. Together with Japan and other Asian countries, it is believed that production volumes of surimi could be more than 1.5 million MT annually.

Surimi production in Southeast Asia in the early 1970s was almost nil and limited only to the production of traditional comminuted fish products — fish balls and fish cakes. With the advent of improved fisheries post-harvest technology being disseminated to the region through the capacity building activities of MFRD, surimi industry in Southeast Asia has significantly prospered. Thus, surimi has since then been used to produce quality fish balls, fish cakes, fish sausage, fish burgers, *chikuwa*, imitation crab stick, among others, not only for domestic consumption but also for export.

Surimi Top-producing Countries in Southeast Asia

Demersal fishes belonging to five families — Synodontidae, Priacanthidae, Sciaenidae, Nemipteridae, and Mullidae — have been used as raw materials for the production of surimi in the Southeast Asian region. The region's production of these fish species had been increasing from the mid-1970s to mid-2000s with Indonesia, Thailand, Malaysia, and the Philippines emerging as top producers (Siriporn *et al.*, 2007). In recent years however, the region's production of these fish species had exhibited decreasing trend, especially from Thailand since its demersal fishery resources had been declining. After 2005, production of such fishes had further dwindled as shown in **Table 1**, evoking certain doubts on the capability of these fishery resources to continue contributing to the sustained production of surimi in the Southeast Asian region. In fact, the Vietnamese Association of Seafood Exporters and Producers reported on 29 April 2014 that the global surimi production in 2013 decreased by about 8% from 2012 production due to the decreased surimi production in Southeast Asia brought about by low supply of raw materials.

Notwithstanding the possibility that production of the fish species commonly used for surimi production could still improve with increased production from Myanmar and

Table 1. Total production of fish species used as raw materials for surimi by five countries in 2006-2012*: Indonesia, Malaysia, Myanmar (only for 2010), Philippines, Thailand (in metric tons (MT))

	2006	2007	2008	2009	2010	2011	2012
Synodontidae	101,149	108,880	77,324	82,308	80,777	82,531	103,110
Priacanthidae	136,835	131,754	66,300	72,102	94,812	91,422	98,725
Sciaenidae	133,511	132,872	118,031	121,340	145,298	141,995	142,334
Nemipteridae	296,706	316,308	177,524	174,976	278,806	188,256	157,202
Mullidae	85,694	85,432	79,604	107,673	187,735	123,590	132,705
Total**	753,895	775,246	518,783	558,399	**787,428	627,824	634,076

* Production from mid-1970s to mid-2000s was reported in Siriporn et al. (2007)
 ** Includes reported production of Myanmar for Sciaenidae, Nemipteridae, and Mullidae for 2010
 Sources: SEAFDEC (2009; 2010; 2010a; 2011; 2012; 2014)

marine fisheries production of Viet Nam could be classified according to species specifying actual production of raw materials for surimi, MFRD launched an intensified program on the maximum utilization of the fishery resources. The program had two-pronged objectives — minimizing pressure on capture fisheries considering that the level of harvest in capture fisheries is not likely to increase significantly, and ensuring that most of fish catch is directed to human consumption thus mitigating possible shortage in food supply.

Nevertheless, the Southeast Asian region continues to supply the world market with surimi. Records have shown that in 2012, Viet Nam emerged as one of the world’s top three producers of surimi. The value of the country’s surimi export was reported in 2012 to be US\$275 million increasing by about 36% from that of 2011. As of 2012, there were 19 companies producing surimi in the country. Thailand is also among the world’s top producers of surimi. Since 2005, the country has been producing surimi at an annual average of 150,000 MT (Somboon *et al.*, 2009) from 21 companies specializing in surimi production.

Starting in 2005, Myanmar has been producing surimi at an annual average of 12,000 MT/year from 5 companies, and Indonesia has been exporting surimi at 8,000 MT/year produced by the country’s 8 companies engaged in surimi production. Meanwhile, Malaysia had 6 companies producing a total of 100,000 MT of surimi in 2005-2006 (Siriporn *et al.*, 2007; Somboon *et al.*, 2009). There is still a great chance that surimi production in the Southeast Asian countries could increase in the next decades, despite slow increase in the trend of production of marine fish species as raw materials as could be gleaned from **Table 1**. This is because aside from the efforts of many Southeast Asian countries to promote sustainable management of the fisheries, many under-utilized freshwater fishes have also been tried as raw materials for producing surimi after the mechanisms of gel-formation and their gel-forming properties had been clarified and established by MFRD. Moreover, technological advancements in surimi production are being picked up rapidly and adapted by the countries considering the high marketability of fish jelly products for

the manufacture of imitation crab sticks, lobster, scallops, clams, shrimps, and other seafood which are highly in demand not only in Japan but also in the EU and USA, making surimi an international commodity. Nevertheless, there is a need to continue improving the fisheries post-harvest technologies adopted in the region to make sure that the region’s fishery products including surimi, could compete with those of the other regions in the world.

Role of SEAFDEC in the Improved Fisheries Post-harvest Technology in Southeast Asia

In fulfilling the objective of food security and socio-economic stability in the Southeast Asian region, SEAFDEC deemed it necessary to improve fisheries post-harvest technologies to ensure that the region’s fish and fishery products are of good quality and safe not only for export but also for domestic consumption. Besides, SEAFDEC also recognizes that it is very crucial for the Southeast Asian region to enhance the promotion of sustainable fisheries post-harvest technologies in order to secure the niche of the region’s fish and fishery products in the world market, as this in turn would largely create great impact on the region’s economies. Thus, began the saga of fisheries post-harvest technology development in Southeast Asia.

It is along the premise of securing the niche of the region’s fish and fishery products in the world market while ensuring food security in the Southeast Asian region that SEAFDEC/MFRD in collaboration with the Agri-Food & Veterinary Authority (AVA) of Singapore through its Post-Harvest Technology Centre (PHTC) embarked on projects that aim to intensify the development of fisheries post-harvest technologies in Southeast Asia. Specifically, such projects seek to optimize the utilization of catch and reduce post-harvest losses, improve quality of traditional fish products and promote rational utilization of by-products through responsible processing, and institute measures to comply with international safety requirements. As soon as appropriate technologies have been developed by MFRD, these were immediately transferred to the ASEAN Member

States (AMSs), through capacity building with funding support provided by the Japanese Trust Fund. The capacity building scheme advanced by MFRD includes institutional enhancement and human resource development, as well as standardization of post-harvest procedures and analytical methodologies for the AMSs (Yeap and Chow, 2011). As a result, the fish processing industry in the whole Southeast Asian region had immensely improved leading to the upswing of sustainable processing efforts in the region including increased production of surimi.

In 2001 however, a deep concern was expressed over the level of harvest in marine capture fisheries which had not been significantly increasing that could affect the socio-economic condition of relevant stakeholders. In order to address such concern and ensure that maximum benefits could still be obtained by the stakeholders while more fish products would go for human consumption, it was a general consensus in the region to maximize the value of existing fish catch and at the same time, reduce post-harvest losses. Against this backdrop, the Ministers from the AMSs responsible for fisheries adopted the First ASEAN Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region during the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security in the New Millennium: Fish for the People in November 2001 in Thailand.

Specifically for the region's fish and fishery products, the 2001 Resolution provided that "*maximum utilization of catch including the reduction of discards and post-harvest losses should be promoted to increase fish supply and improve economic returns*"; and that "*post-harvest technologies should be improved to ensure fish quality assurance and safety management systems which are appropriate for small- and medium-sized enterprises in the region, taking into account the importance of traditional fish products and food safety requirements*". Such provisions had fired up the enthusiasm of the researchers from MFRD to intensify the sustainable development of fisheries post-harvest technologies that would ensure the sustainable utilization of fish catch.

Moreover, SEAFDEC also acknowledged the need for the region to enhance its capability in food safety and quality assurance of fish and fishery products to be able to conform to international requirements such as the FAO Code of Conduct for Responsible Fisheries (CCRF) adopted in 1995. The CCRF provides the necessary framework for national and international efforts to ensure sustainable exploitation of aquatic living resources and fish trade in harmony with the environment. In order to facilitate its implementation at national level, SEAFDEC embarked on a project to regionalize the CCRF by examining, clarifying and elaborating the generic provisions, and finally establishing

a set of regional guidelines taking into account the regional specificities of fisheries in Southeast Asia. Thus, the Regional Guidelines for Responsible Fisheries in Southeast Asia: Responsible Post-harvest Practices and Trade (SEAFDEC, 2005) had been developed and promoted in the Southeast Asian region to assist the AMSs in implementing the CCRF, specifically those provisions that pertain to fisheries post-harvest practices and trade.

As significant improvements in the utilization of fish for human consumption continue to take shape in the region, the Ministers from the AMSs responsible for fisheries considered it imperative to "*respond to the challenges of the changing environment and the emerging issues including climate change and the growing gap between the increased demand for fish and fishery products and ASEAN's ability to supply these products in a sustainable manner, and taking into account the imperative to minimize the impacts caused by the increasing pressures on fisheries and globalization of trade*", among others. In this connection, the Ministers adopted the superseding Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 (SEAFDEC, 2011a) during the ASEAN-SEAFDEC Conference on Sustainable Fisheries for Food Security Towards 2020 "Fish for the People 2020: Adaptation to a Changing Environment" organized in Thailand in June 2011.

The 2011 Resolution relevant to fisheries post-harvest stipulates that "*the utilization of catch from water to market should be optimized by reducing post-harvest losses and wastes to increase fish supply and improve economic returns through promotion of appropriate technologies and facilities along the supply chain, and that technologies and facilities should be improved to ensure fish quality assurance and safety management systems, taking account the importance of traditional fishery products and food security requirements, and the development of fishery products should be promoted as an alternative supplementary livelihoods for fisheries communities*". These frameworks have served as guide for MFRD to sustain its activities on value-adding of fish catch for human consumption.

Optimum utilization of fishery resources and minimum wastage of fishery resources

Although in Southeast Asia most of fish catch is actually utilized, in most cases the high-value catch goes mainly for human consumption while the low-value fishes are turned into products for non-human consumption, *e.g.* fish meal for animal feeds. Meanwhile, on board fishing vessels the high-value of the catch could be diminished to low-value due to poor handling onboard giving less benefit to the fishers. It is in this aspect that improvements of techniques in fish handling onboard had been undertaken by SEAFDEC in order that the quality of catch from fishing grounds to

the ports is maintained. Promoted in the region by MFRD, such initiatives resulted in improvements of on-shore fish handling and transport as well as advancements in storage and transport facilities.

Furthermore, MFRD also works on the optimum utilization of fish catch in order that fishers and other relevant stakeholders get the best economic benefit from their catch while the supply of quality and safe fish and fishery products for human consumption could be increased contributing to the food security of peoples in the region. From the technological advancements attained by MFRD, many new fishery products have been developed by the Southeast Asian countries not only for the domestic market but also for export. As a matter of fact, products such as fish balls, fish cakes, imitation crab sticks, imitation shrimps, breaded squid rings, breaded fish or shrimp, fish crackers, fish skins, and the like, could now be seen in local supermarkets' shelves, especially in urban centers of many Southeast Asian countries.

Nevertheless, the concern on responsible utilization of low-value fish catch still continues to loom over the region as reports seem to suggest that more low-value marine fishes have been diverted away from human consumption to give way to the manufacture of high-demand fish meal for animal feeds. MFRD therefore intensified its efforts in ensuring that quality value-added products could also be derived from low-value and under-utilized freshwater fishes to sustain the economic benefit that could be obtained by fishers and relevant stakeholders. Following the prescribed safety and quality standards for fishery products, quality value-added products had been produced from such freshwater species as the featherback (*Notopterus* spp.), snakehead (*Channa micropeltes*), moonlight gourami (*Trichogaster microlepis*), and soldier river barb (*Cyclocheilichthys enoplos*). More particularly, the minced meat of the featherback and snakehead fish has been used to produce the value-added product fish *bah kwa*, and that of the soldier river barb has been used to produce the value-added fish snack, fish *murukku*.

With the main objective of improving livelihoods in inland fishing communities, the technologies developed by MFRD on sustainable processing and value-adding of freshwater fishes have been extended to the ASEAN countries through the initiative of the Government of Singapore. Thus, the PHTC of the country's AVA, as the Collaborating Center for MFRD Programmes carried out a three-year project aimed at promoting the optimum utilization of indigenous freshwater species through the development of value-added products, and upgrading the processing and packaging technology for freshwater fish products for commercialization. Through capacity building, the participating countries, namely: Indonesia, Lao PDR, Myanmar, and Viet Nam were able to undertake value-added product development and processing

trials using indigenous freshwater fishes. After the project implementation, a processing handbook on *Utilization of Freshwater Fish for Value-added Products* which contains descriptions of freshwater fisheries in the participating countries, freshwater species used in processing, value-added products developed, processing steps and procedures, and shelf-life studies, was published and disseminated to the Southeast Asian countries.

In another development and guided by the Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2010 which stipulates the need to “introduce and provide support for the development and application of technologies that optimize the utilization of catches, reduce post-harvest losses, wastes and discards in commercial and small-scale fisheries and processing operations, ...”, MFRD embarked on activities that were aimed at turning fish trimmings and fish processing by-products into fishery products.

Considering that the Southeast Asian region is a major producer and exporter of tuna in fresh, frozen, chilled or canned forms, some amounts of trimmings and other by-products that are considered as discards could be generated during the processing. Thus, MFRD had been developing value-added products for human consumption from tuna trimmings (Yeap and Chow, 2011) such as breaded and battered tuna products for the production of tuna burger and tuna loaf as well as tuna sausage and tuna pico (small chunks and chips). The technology had been easily picked up by the Southeast Asian countries resulting in the development of value-added products from by-products of their respective fish processing industries.

Quality improvement of traditional fish products

In the Southeast Asian region, traditional fish products — fish sauce and cured fish such as sun-dried, salted and dried, steamed or boiled, fermented, and the like — are major source of micronutrients and animal protein of the populace. Many reports have indicated that 30-45% of fish landed in many Southeast Asian countries are converted into traditional fish products as important means of preserving fish when storage facilities for fresh fish are inadequate. Usually consumed by low-income members of the society, traditional fish products are mostly produced in backyards using low-level technology but such initiative has always served as source of income and rural livelihoods in many fishing communities. In the marketing system however, products from backyard processing could not easily compete with those produced from modern processing industry, especially in terms of quality and quantity, undermining the socio-economic advantage that could be derived by the backyard fish processing industry.

Nonetheless, the traditional fish processing industry has been constrained not only in terms of insufficiency of raw

materials but also the low quality of the raw materials, outdated processing and preservation technologies, packaging that remains unappealing to consumers, and marketing practices that seem unreasonable. The latter of which is influenced by the existing pricing structure that dictates low prices for traditional fish products, especially those produced by the backyard fish processing industry. The immediate consequence is the inability and unwillingness of producers not only in improving the quality and safety of their products but also in enhancing their processing operations. Thus, SEAFDEC deemed it necessary to address such concerns and come up with strategies to improve the quality, marketing and trade of traditional fish products from the region. Towards this end, MFRD heeded the call of the AMSs which was specified in the Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020, that “*production of and preserving the diversity of traditional fish products should be promoted by assisting producers to secure stable supplies of quality raw materials, meet food safety requirements and to improve product identity, nutritive value and marketing*”. With such provision, MFRD had advocated through its human resource development activities, the development of HACCP (Hazard Analysis and Critical Control Point) plans for traditional fishery products in the AMSs and improvement of the respective countries’ local processing industries. Furthermore, MFRD also promoted the mechanization of the processing industry as well as automation of the production line to increase productivity. Thus, through the efforts of MFRD, the region’s commonly-used fish processing equipment had not only been modified to suit the capability of the countries but also ensuring that the performance and efficiency of the equipment are maintained.

Measures for Fishery Products from the AMSs to Comply with International Safety Requirements

Traditionally, fish products from the AMSs are generally bound for domestic consumption and largely manufactured by small and medium enterprises, and to a certain extent in backyard processing industries. However, some countries have the potentials to export their fishery products to developed countries such as Japan, the EU and USA. Nonetheless, most processors of traditional fish products in Southeast Asia make use of fish by-catch or low-value fish as raw materials, making production not only seasonal but also to some extent, are of low-quality (Yeap *et al.*, 2007). In addition, processors are not well-educated, have inadequate knowledge in preservation and processing techniques, and little access to skills development and information on food hygiene. These factors contribute to the difficulty in complying with safety and quality standards and requirements of fishery products traded in the world market. Moreover, many countries in the region have not

yet established the necessary regulations and standards on quality, safety and hygiene for fishery products that meet the requirements of the domestic as well as foreign markets. Along this argument, AMSs explicitly expressed in the Resolution on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020 the need to “*improve technologies and facilities to ensure fish quality assurance and safety management systems, taking into account the importance of traditional fishery products and food security requirements, and promote the development of fishery products as an alternative supplementary livelihood for fisheries communities*”.

All the while however, MFRD had been addressing such concern through its projects and activities that aim to develop appropriate guidelines in food safety measures such as good manufacturing practices (GMP) and standard sanitation operating procedure (SSOP). MFRD also provided assistance to small and medium enterprises (SMEs) in implementing the said food safety measures. Specifically, the project of MFRD on Quality Assurance Systems for Small- and Medium-sized Fish Processing Establishments developed the necessary quality assurance systems for the SMEs that incorporate GMP/SSOP programs as first step towards the implementation of HACCP systems and eventually helped the SMEs meet safety and quality assurance requirements. Manuals on GMP/SSOP and corresponding guidelines were produced by MFRD and distributed to the AMSs to assist the countries in the conduct of their respective national training programs, which could eventually facilitate compliance of the Southeast Asian countries with international standards for fishery products.

Way Forward

The Codex Alimentarius: Code of Conduct for Fish and Fishery Products provides the specific requirements and techniques to preserve the nutritional quality of fish and fishery products, as well as extend the shelf-life, minimize the activity of spoilage bacteria and avoid losses caused by poor handling (WHO and FAO, 2009). As reported by FAO (2012), fish for direct human consumption marketed as live, fresh or chilled constitutes about 47% of total fish catch while frozen fish constitutes about 29%, and prepared or preserved and cured fish about 24% of total catch. The preservation and curing methods differ by continent, region and country. In Southeast Asia, a number of prepared and cured products are generated in addition to processed products in the form of surimi which is mainly for export.

In order to continue adding value of the fish catch and producing quality fishery products for sustainable development and food security in the Southeast Asian region, SEAFDEC would enhance the development of fisheries post-harvest technology through the regional programs

Box 1. Requirements and preservation techniques for fish and fishery products prescribed by Codex Alimentarius Commission

The Codex Alimentarius Commission (CAC) develops Standards, Codes of Practice, and Guidelines in the area of food safety and fair practices in trade. The Standards specify the characteristics of food products, while the Codes of Practice identify the procedures that national competent authorities and operators in the food chain need to follow in order to reach those Standards. The Guidelines identify steps that need to be taken to protect consumers' health from certain specific food hazards. Standards, Codes of Practice and Guidelines are continuously updated, and new sections are added as required. Recent work by the CAC has led to: (i) adoption of Standards for live and raw bivalve molluscs and fish sauce; (ii) updating of the Code of Practice for Fish and Fishery Products with sections on live and raw bivalve molluscs and smoked fish; and (iii) adoption of Guidelines on the Application of General Principles of Food Hygiene to the Control of Pathogenic *Vibrio* Species in Seafood.

being carried out by the PHTC of AVA as the Collaborating Center of SEAFDEC to undertake the activities of MFRD. Specifically, the projects and activities of MFRD would cover R&D in fisheries post-harvest technology to include optimizing the utilization of available fisheries resources; developing fishery products from under-utilized resources for the sustainable production of surimi and value-added products such as fish balls, fish cakes, fish sausage, fish burgers, fish *bah kwa*, and fish *murukku*; ensuring seafood safety by monitoring chemical contaminants in fish and fishery products such as heavy metals, antibiotic and pesticide residues, and marine biotoxins; promoting seafood quality assurance for handling and quality preservation, as well as application of HACCP and GMP to fish processing establishments in the region; and instituting traceability systems for aquaculture products. In all these efforts, adherence to Codex Alimentarius would be assured, including the safety standards developed by the Codex Alimentarius Commission as shown in **Box 1** (FAO, 2012).

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