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"Development of Alternatives to the Use of Freshwater Low Value Fish for Aquaculture in the Lower Mekong Basin of Cambodia and Vietnam: Implications for Livelihoods, Production and Markets"

Investigation 5 (07FSV01UC) - Phase 1

Maximizing the utilization of low value or small size fish for human consumption through appropriate value added product development

Final Technical Report

Research topic 1: **SMALL-SIZED FISH PASTE PRODUCTION TECHNOLOGY IN CAMBODIA'S MEKONG RIVER BASIN**

So Nam[1], Norng Chakriya[2], Leng Sy Vann[1], and Pomeroy Robert[3]

[1] Inland Fisheries Research and Development Institute (IFReDI), Fisheries Administration, Phnom Penh, Cambodia

[2] Royal University of Agriculture, Phnom Penh, Cambodia

[3] University of Connecticut, USA

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Abstract

Fish have long been critical to all Cambodians. It is a major source of nutritious food in the daily diet, a primary source of income and has strong cultural and religious significance. Fish matter a great deal to the millions of people who live on the banks of the country's rivers, particularly those living in and around the Tonle Sap Great Lake. Cambodians are considered one of the highest per capita consumers of freshwater fish in the world (a recent estimate of 52.4 kg per person per year from household surveys, being equal to 81.5% of the total animal protein intake).

There is an abundance of small-sized/low value fish harvested using *dai* "bag-net" and many of other fishing gears in a short period during the peak fishing season (December–March) along the Tonle Sap and Mekong rivers, and their major tributaries. These fish are typically landed in many (isolated) locations and in a poor condition or severely damaged from the capture methods. During the peak season, thousands of people travel to the Tonle Sap, the Mekong and other waterways to trade rice for fish, to fish themselves, or to buy small-sized/low value fish to produce fermented fish paste. Fermented fish paste is an excellent food for the elderly or small children. Fish paste is one of several fermented fish products, which is preferable and kept for use in all Cambodian houses. Small-sized/low value fish paste is divided into two kinds, boneless and bony fish paste, produced by different fermented technologies. It is bought and used by different classes of people. The bony small-sized fish paste, which can also be called low-valued fish paste, is mostly consumed by the poor who have limited income.

This paper provides a clear understanding of the processing techniques of fermented small-sized/low value fish in Cambodia's Mekong basin. The paper will address five specific topics: (1) document both traditional and modern existing technologies of fermentation process of small size fish paste; (2) recommend best management practices of fermentation techniques of small-sized/low-value fish; (3) identify problems and issues relating to small-sized fish fermenting practices and value-added product development; (4) analyze economic aspects of small-sized fish paste production; and (5) recommend maximizing the utilization of small-sized or low-value fish paste for human consumption through appropriate value added product development. The data for the paper is based on interviews with 100 micro-, small-, medium- and large-scale small-size fish fermenting operators in five provinces of Kandal, Kampong Chhnang, Battambang, Siem Reap, and Phnom Penh located in the four major river branches of the Cambodia's Mekong River basin, with a distance of over 500 km, using standard semi-open questionnaires.

Introduction

Cambodia is traditionally a fish-eating country. Most of Cambodian people prefer freshwater fish rather than marine and raised fish, especially for people who live around fresh water body and those living in the upland areas. Moreover, the fresh water fish is an important supply for traditional food such as fish paste, fermented fish, smoked fish, salted fish, and fish-sauce and is a source of protein, wealth and livelihood opportunities for millions. More than 102 million people in the Tonle Sap area alone depend on fishing for their livelihoods (Van Zalinge et al., 2001a).

Hortle et al (2005) stated that thousands of tons of small-size or low-marketed value fish are caught each year in the Cambodia Mekong basin. It is estimated that at least 16,000 tons was caught by using only one commercial type of fishing gear–bag net or Dai fisheries in the 2004-2005 season. About 50% of total catch in the Tonle Sap is Trey Riel (*Cirrhinus siamensis* and *C. cryptopogon*) (Hortle et al., 2004) and contributes 22% of the total inland fish catch in 2004. So et al (2007) reported that more than 95 percent of total dai fish catch is low value or small-sized fish. The most dominant species is trey riel (Cirrhinus spp., 52%), followed by trey slak russey (*Paralaubuca typus*, 20%), trey khnorng veng (*Labiobarbus spp*., 12%), and trey bandol ampeou (*Corica laciniata*, 5%).

Small-sized fish are also used for producing fish and other animal meal and for human consumption (So et al, 2005). Prahoc is fermented fish paste and is produced from small low-value fish such as trey riel (Hortle, et al., 2004). Prahoc is a very popular food ingredient in Cambodia. Production methods are different based on locality and tradition. In Cambodia small-size fish processing has been practiced in 4 forms: large-, medium-, small-, and micro-scales of fish processing.

The overall objective in this research was to study the methodologies of fermented small-sized fish processing technologies in Cambodia. The specific objectives of the research are as follows:

1. To review existing methodologies/technologies of small-sized fish paste (Prohoc) processing.
2. To identify the best management practices of Prohoc production in fermented small-sized fish processing practices.
3. To identify problems relating to small-sized fish paste processing practices and value-added product development
4. To analyze economic aspect of fermented small-sized fish (Prohoc) production.

1. Methods and materials

1.1 Study site selection

The selection of the study areas were based on: 1) location of fermented small-sized fish paste processing, and 2) potential for the development of fermented small-sized fish paste. Five provinces/cities located along the Tonle Sap River were selected for study areas and these provinces/cities include (see figure 1):

- Phnom Penh city, the studies were conducted on Russey Keo Khan, Chrang Chomres1 and Kilometre N09 Sangkat, N0 3, N0 4, and Chrang Chomres Village.
- Kandal Province conducted on Pongnea Leu, Poung Mongkul District, Prek Pnoav, Kompong Lourng, and Pongnea Leu commue, Phoum Thmei, Dourng, Son Vor, Kandal, and Kruos Village,

- Kampong Chhnang Province conducted on Kampong Chhnang District, Psar Chhnang, and Psar Ler commue, Kandal, Dey Dorl, Choung Kors, Kampong Brasath, and Preak Reang Village.
- Battambang province conducted on Ek Phnom District, Prek Norin commue, Prek Ta Chraeng Village.
- Siem Reap Province conducted on Siem Reap District, Siem Reap and Chorng Khneas Commue, A Raagn, Pou Bonteay Chey, Pou,Chorng Khneas.

Figure 1

1.2 Sample justification and sampling method and size description

The fisheries administration cantonment officers were contacted because they know all the addresses of fermented small-sized fish paste producers/households in the provinces and cities. The sampled producers/households were selected from a discussion with the fisheries administration cantonment. This sampling method was used because outsiders do not know the producers/households in the areas. A hundred producers/households were selected from five provinces/cities located along the Bassac River, and Tonle Sap Great Lake. The samples were selected purposively. There are 20 producers/households selected in each province/city of Phnom Penh, Kandal, Kampong Chhnang, Battambang and Siem Reap for the interviews.

1.3 Data collection

1.3.1 Secondary data

The secondary data was obtained from related relevant institutions such as: Department of Agro-industries, Department of Fisheries (Ministry of Agriculture Forestry and Fisheries), Ministry of Industry Mines and Energy, books, journal, Ministry of Commerce and reports from each district of target study area related to background information on the study areas.

1.3.2 Primary data

The primary data were collected through the following:

a) Questionnaire survey

This was the main source to collect primary data in this research. For this purpose, a questionnaire was designed to acquire data from sampled producers/households. To test the suitability of the questionnaire, a pilot survey was conducted in the first week of actual field work. Some modifications were made after the pilot survey (see appendix 1).

b) Interview of fish processors

Formal and informal discussions were conducted with officials and producers/households from different scale producers. 100 fish processors were interviewed with questionnaires to collect primary data on techniques of fish processing and market of fish processing as well as economic analysis of fish processing (see appendix 1). About 20 fish processors in each of the five provinces Phnom Penh, Kandal, Kampong Chhnang, Battambang and Siem Reap were selected for the interviews.

c) Observation

Observation was conducted to see and monitor characteristic features of producers/households, workers, fresh fish, types of machines, place of fermented, and fish

paste product. This was done to know about characteristics of fish processors. The large-scale fish processors have a huge place and modern equipment to produce fish paste with big volume of products. The purpose of the production is targeted for domestic and export sale; but the micro-scale fish producer has a small place and traditional equipment to produce with the aim of the producing consumption for the family.

1.4 Data analysis

The research has two kinds of data: quantitative and qualitative data. The data was entered in Microsoft Excel and SPSS program. Data interpretation was analyzed with data description, cross tabulation, and multiple responses. Moreover, economic efficiency analysis was used to compare the ability of each fish processors in different scale. These formulas were detailed as following:

- Gross margin or Net profit analysis: This was used to determine the costs and return involved in Prahoc production.
- Fundamental formulas for a specific time period, usually on year, are listed here. NP or GM = TR – TC
- Net profit (NP) or Gross Margin (GM) =Total Revenues (TR) minus Total Costs (TC) for one year. TR= Q x P
- Total Revenues (TR) or Income = Total number (quantity) of items sold times the price (P) of each item sold throughout the year. TC or Expend = TFC + TVC
- TC = Total Fixed Cost (TFC) + Total Variable Costs (TVC).
- TFC = Annual costs that do not vary during the year or Summation of all fixed cost.
- TVC = Costs that will vary with production levels or Summation of all variable cost. Net income = GM or NP – TFC
- Profit (II) = Gross Margin (GM) - Total Fixed Cost (TFC): E.E = TR/TC
- Economic Efficiency = Total Revenue (TR) divided by Total Cost (TC)

2. Results

2.1 Document small size fish processing practices

The techniques of fish processing are different with different location and scale. In Cambodia, there are four scales of fish processing practices identified based on interviews with fish processors and Fisheries Cantonment Officers in target area of the study. There are two kinds of prahok products that those fish processors produced such as boneless and bony prahok. The fish processing is practiced with two kinds of fermented fish processing techniques: traditional and modern. Those techniques use different facilities and quality products.

Traditional techniques:

a. Small-scale: This processing is common practice for Cambodian people who prefer processed fish products like fish paste, fermented fish, fish sauce, sun dried and salted-dried fish, smoked fish, and steamed fish. This processing is very well-adapted to the irregularity of seasonal fish catch. Because the period of catch is a very short period, it is necessary to process fish quickly and the private families/laborers have a basic role in this processing. Although the final product has low quality, it is a way of handling the large amount of fish during the peak period. In general, small-scale fish processing is an activity of households who produce for family consumption. These are people living near the river, fishing lots, lakes and also people who live in upland areas. Few

family fisheries producers are registered businesses. These producers produce low-value, locally purchased fish sauces, pastes, and dried fish.

b. Medium-scale: Fish processing usually is done by households, which operate by using family labor, their relatives, and some hired laborers during the peak period. Their location is usually near the fishing lots, fishing villages and landing places. Generally, they make dry salted fish, smoked fish, Pho-ork (fermented fish), etc. Since there is a market for sun-dried fish for animal feed, its production has expanded in the last few years and it is exported to Vietnam.
c. Large-scale: Generally, processing is operated by fisheries enterprises and fish sauce factories. Usually, they employ 40-60 workers (most of them are women) who are involved in the activities of transforming the raw material into dry salted fish products, ordinary fish pastes and boneless fish pasted (high value).

Modern Processing Technology

a) Small-scale: The annual fish input is less than one ton. Production is done using a boiling process usually by a household. The sauce is used for home consumption and exchanged for food and other basic supplies. No license is required.
b) Medium-scale: The annual fish input is less than 50 tons. Sauce is made using a boiling process mainly for commercial purposes. Lower investment in equipment, raw materials and labor compared to large-scale production. A license to run the business is also required and is issued by either provincial or central government institutions (DoF and MIME).
c) Large scale: The annual fish input is always more than 50 tons. Sauce is produced for commercial purposes by hydrolysis process, and production involves large investment and relatively high operational costs. Operation requires a license from MIME.

Experiences in fish processing practices include:

a) Experience of small-sized fish processing practice in Phnom Penh and Kandal

Fish processors in Phnom Penh and Kandal produce bony prahok. There are many steps to make such prahok based on their experiences and tradition. Each step is described as following (see Figure 2):

- Fish preparation: Fish used for processing are fresh fish that are bought from dai or fishers nearby. Fish species for processing are white fish species. Trei reil, are 70-95%, and Kaek, Achkok, Reusesey and Kanhchhrouk are 5-30% of the total amount of fish processed.
- Fish beheading: Producers used machine to behead fish. Fish were stirred by beheading machine until almost scales are removed for about 10 minutes per sample. There are two types of beheading machine: small machine that can store 300 kilograms and large machine that can 700 kilograms of fresh fish. If producers take low-quality fish for processing, it is easy to lose some fish weight. It is a good beheading when the fish become white with no head or scales. Micro-scale beheading of fish does not use a machine – it is done by hand with the use of a knife. Fish is cut one by one. Sometimes farmers have bought mini-processing machines for fish (screened fish) to make Prahoc.
- Screening: Beheaded and scaled fish will now flow through a screening machine. There are two types of screening machines: one that is used with pub and one that is used to dip with a container from beheading machine. From fish-dipping or shoveling stage to screening stage takes about 30 minutes. Producers spray water on the fish, on screening machine, and in this process fish heads are selected by workers. When screening is finished, fish are put in packets or basket or boat plank to drop in water

about 2-3 hours. In the case of huge packets or baskets of fresh fish, producers will immediately load the screened fish in the boat. In the case of little fresh fish, producers keep the screened fish in the water.

- Fish ripening: Fish were ripened on patio about one cycle or 12-24 hours. This results in good-quality, good-smell Prahoc. This stage does not use any salt.
- Fish salting: Swelled fish is blended with salt. Producers blend 1 ton of fish with 200 kilograms of salt. Then it is ripened for one cycle or from 12-24 hours.
- Storing: Fish are tripped to flow out wild water after that were added with some salt to store in jar/tank/vat. Two kinds of salt are used: white and grey, using a ratio of 1:2. Salt fish are pressed together for tight storage. Salt covers the jar/tank/vat with a thickness of 3-5 centimeters from insects or dust. This step could use about 200 kilograms more. Good-quality Prahoc is stored for 6-12 months. But when there is a high consumer demand, producers mix old Prahoc with new Prahoc to sell more.

Figure 2

b) Experience of small-sized fish processing practices in Kampong Chhange

It is the same for fish processors in Phnom Penh and Kandal. Those fish processors produce bony prahok. There are many steps to make prahok based on their experiences and tradition and each step is described as following (see Figure 3):

- Fish preparation: Fish used are fresh small-sized fish that is bought from dai or fishermen in the river. They are white fish varieties: Trei reil are 70-95%, and Kaek, Achkok, Reussey and Kanhchhrouk have only 5-30% of the total amount.
- Fish beheading: Fish are beheaded by machine. Beheading machines have stirred fish until no scales are left for about 10-20 minutes per 300-700 kilogram. There are two types of beheading machines: small machine could store amount 300 kilograms and large machine could store amount 700 kilograms of fresh fish. If producers take low-quality fish for processing, it is easy to lose some fish weight. It is a good beheading when the fish become white with no head or scales. Micro-scale beheading of fish does not use a machine – it is done by hand with the use of a knife. Fish is cut one by one. Sometimes farmers have bought mini-processing machines for fish (screened fish) to make Prahoc.
- Screening: Beheaded and scaled fish will now flow through a screening machine. There are two types of screening machines: one that is used with pub and one that is used to dip with a container from beheading machine. From fish-dipping or shoveling stage to screening stage takes about 30 minutes. Producers spray water on the fish, on screening machine, and in this process fish heads are selected by workers. When screening is finished, fish are put in packets or basket or boat plank to drop in water about 2-3 hours. In the case of huge packets or baskets of fresh fish, producers will immediately load the screened fish in the boat. In the case of little fresh fish, producers keep the screened fish in the water.
- Fish salting: Dropped fish are mixed with salt. Most of salted fish in Kampong Chhnang province are mixed with a large amount of salt to become hard fish. Salting is done only one time in the process. 1 ton of fish needs 100 kilograms of salt. But fish must not become swollen. Fish salting is one method to make Vietnam's *mum*. Since most producers on the boat are Khmer-Viet, most *mum* are exported to Vietnam by boat.
- Storing: *Mum* fish is stored in the boat. One boat can store about 15-20 tons. In peak season, storage of fish in the boat sometimes is often only for one day and then it is exported. Otherwise, producers sometimes store fish for one or two weeks.

Figure 3

c) Experience of small-sized fish processing practices in Battangbang

Fish processors in Battangbang also produce bony prahok and there are many steps to make such prahok. Each step is detailed as following (see Figure 4)

- Fish preparation: In general fish used for processing are kind of salty fish in the river. Small-sized or white fish sometimes are taken from Kampong Chhnang province. Salty fish in the river are beheaded and mixed with a little of salt. Sometimes, those small-sized or white fish are un-clean and low-quality. Trei Khomphlean and white fish such as Trei reil, Kaek, Achkok, Reussey and Kanhchhrouk are used for small-sized fish processing in Battambang province. Trei reil (70-95%) are used more than Kaek, Achkok, Reusesy and Kanhchhrouk are (5-30%) (Table 4.18). There are two kinds of raw material used for making Prahoc: fish and salt.
- Fish salting: Fish were salted in the river (called salty fish). More salt is often added to (1 ton salt is used for about 60-100 kilograms salty fish). Salted fish are put in jar/vat immediately in peak season of fish. Sometimes, fish were put on the concrete and kept about 3-4 hours flowing out of wild water. Sometimes, fish are very unclean. It needs to be washed again with machine and mixed again with salt. Doing like this does not damage the fish meat but gives it a good smell and longer shelf life.
- Storing: Fish are covered with flow-out wild water after it has salt has been added to store in jar/tank/vat. This step uses two kinds of salt: white and grey using a ratio of 1:2. Salty fish are pressed together for tight storage. 3-5 centimeters of salt is used to cover the jar/tank/wool box from flies or dust. 200 kilograms or more or salt may be needed.

Figure 4

d) Experience of small size fish processing practices in Seam Riep

Fish processors in Seam Riep produce boneless prahok. There are many steps to make prahok, however, some steps are different from fish processors in Phnom Penh, Kandal, and Bantanbang. Each steps is detailed as following (see Figure 5)

- Fish preparation: Almost all small-sized fish used for processing in Siem Reap are Trei Khomphlean and this kind of fish makes a good boneless Prahoc. Trei Khomphlean boneless Prahoc is the best taste for Cambodians. The fish preparation in this province is different from other provinces. Trei Khomphlean is used for processing fresh fish.
- Fish scales are scraped and cleaned: Fish are washed and scales are scraped off by using cheesecloth opposite each other in the river until the scales are off and the fish are white. Washing and scale-scraping takes a short time but produces large and clean quantities. The fish are then was soaked to make hard fish. Doing this makes it easier to slice. In general, soaking is done in casks for large fish quantities.
- Fish slicing: Fish are soaked in water in casks until they are hard enough. At that time these fishes are sliced one by one. Fish slicing is from head to end of fish's tail using only one knife. This slicing is done one side at a time side by skinning only the backbone. Knives are used with wooden board to make unbroken fish meat.
- Washing, sun drying and ripening of fish slice: Fish slices are washed with clean water to clean out the stomach for clean and good-quality fish. Fish slice have been dried to trip the water during 1-2 hours to reduce moisture. And then producers take fish slice to soak in water in jar/tank until it floats. This soaking is covered to avoid any flies/dust. This ripening/soaking takes 4-12 hours.

- Fish salting: Fish that float up are put on a shelf. Duration of about 1-2 hours fishes were salted with a ratio of 1:0.3 (1 kilogram of fish to 0.3 kilograms of salt). Proper salt-mixing is very important towards good-quality Prahoc. Jar/tank/cask storage is for 1 day for full salting.
- Decanting of brine and sun-drying of fish slice: Brine is decanted from the fish slice container. This brine is used to make other products. The fish slices are then dried in the shade on the shelf for about 2 hours to make it partially dry.
- Fish salting II: When the fish slices are partially dried, they are pounded with mortar/large foot-powered mortar-and-pestle and mixed with more salt. Salt used with pounding is about 35 kilograms per 100 kilograms of fish slices. But some producers pound fish slices with brine.
- Storing: Salted fishes are stored in jar/tank/wool box with salt cover pressed together for tight storage. After that producers used bamboo strip/stone/sack to cover or pressed on it and then they are poured to immerse in 10 kilograms of salt mixed with 20 liters of pure/cooked water, and then covered using a wooden board/stone to press on it.

Figure 5

2.2 Evaluate small-sized fish processing practices

2.2.1 Consider some points of good quality of fish processing

Table 1 showed some points to be considered for good-quality fermented fish processing. Good-quality prohoc has white color, good smell, a lot of trei riel in fresh fish, hard meat of prohoc fish, soft-meat prohoc, prohoc from which the water has been drained, quality of prohoc or good texture, consumer preference, high price selling, good washing of fish prohoc, good taste, good head-cutting of fish prohoc, meltable in soup, prohoc meat is not dry, free of any artificial chemical, dark brown color, kinds of fish to make prohoc. Good smell is primary among the main points of identified good quality of prohoc production, followed by white color, and then a lot of trei riel in prohoc production, hard meat of prohoc fish, soft meat prohoc, good washing of fish prohoc and dark brown color.

Table 1

2.2.2 Characteristic of fish processing scale

According to the case study, there are 4 scales of fermented fish processing and each scale has a different characteristic (see Table 2). Small-sized fish processing scales were characterized according to the total amount of prohoc produced per year. Table 3 shows the fish processors in study area who are involved in producing fermented fish product. Small-scale prohoc processors were common and dominant, followed by micro-scale processor and middle-scale ones. Large scale processors who could produce more than 1,000 tons of small-sized fish prohoc for export markets were found only in Battambang province.

Table 2

Table 3

2.2.3 Fish processing products

Table 4 showed trends of the fermented fish products in each surveyed province for the last five years. In total, the five provinces produced 7,138 tons in 2008. The total production

increased from 3,969 tons in 2004, representing almost a 2-time increase. Battambang province produced the highest amount of prohoc. This was followed by Siem Reap province. These are the two most popular prohoc-producing provinces.

Table 4

2.2.4 Economic analysis of fermented fish processors

Table 5 shows the economic analysis of fermented fish processors in study area based on each scale which those fish processors practiced. The most economically-efficient prohoc processing scale was the medium-scale, i.e. being an average economic efficiency of 1.6 followed by large-scale (1.4). Micro-scale prohoc processing had the lowest economic efficiency (0.93).

Table 5

2.2.5 Problems encountered in the fish processing practices

Fish processors encountered some problems in the practices of fermented fish processing. Those problems are detailed in Table 6. There were two main problems which were encountered by most of the prohoc producers in Cambodia: (1) high price of salt, and (2) high and increasing price of inland small-sized fish. Two other problems relate to technical problems: (1) unclean beheaded fish, and (2) rancidness. Low price of small-sized fish prohoc was also the other problem due to the dependency on export markets.

Table 6

2.3 Compare traditional and modern processing practices – best management practices of prahok production

Two different practices of fermented fish processing - bony and boneless prahok - are rated to compare with both techniques of fish processing:

2.3.1 Boneless prahok (Prahoc Sach in Khmer)

Traditional processing technique

a. Fish from fish catching place: Fish are covered to prevent water from getting into the boat which could affect fish quality and the products of fish. Fish should be:
   - Put in shade and kept for only a short time (less than 4 hours).
   - Put in clean plastic box and kept in clean place far from pedestrians areas.

b. Hygienic equipment: To protect from contamination, clean equipment must be used.

c. Fish preparation: In general, all kinds of fish were used for Prahoc product. But Trei Khomphlean is the best one for boneless fish-paste processing.

d. Fish cleaning: Microorganisms were reduced by washing before soaking in water in a jar. Unclean or recycled water must not be used so that there will be no microorganisms with fish meat. Fish are dried in the sun for 1-2 hours to reduce moisture from fish meat. Fish are soaked in water until they float. Soaking time is about 4-12 hours.

e. Fish salting practice:
   Step 1: Soaked fish are dried in the shade for about 1 hour to salty fish (100 kilograms of fish with 30 kilograms of salt).
   Step 2: Jar was used to keep Prahoc to ripen for 1 day. The salt was absorbed well from fish slice.

Step 3: Soaked fish in step 2 are drained of brine. This brine could be used for other products. Then salted fish slices are dried on a shelf for about 2 hours.

Step 4: Fish re-salting: 100 kilograms of fish use 35 kilograms of salt. Salting is done by using large foot-powered mortar-and-pestle or large hand-operated mortar and pestle to absorb well.

Step 5: Salt is spread out on the surface of Prahoc, after that bamboo strip are pined and then brine poured on it (the bamboo is immersed in brine). Brine is 5 kilograms of salt mixed with 20 liters of water. At the end, cloth or plastic are used to cover it with wooden board and stone. Prahoc should be tightly stored.

f. Prahoc storage: Jar or any containers should be clean and dried in the sun. Storage containers are inscribed with processing date, Prahoc type (bone or boneless Prahoc), and kinds of fish. Containers must be kept in a clean place.

2.3.2 Bony prahok (Prahoc Cha-eung in Khmer)

Traditional processing technique

The fish are first beheaded by hand, and washed by feet/bamboo stick. Sometimes fish are scaled and eviscerated depending on the number, quality of fish, and the weather. They are then washed in fresh water for about 20 minutes to remove blood and other adherent materials. After that fish are ripened for 8-24 hours to allow it to develop its characteristic flavor and texture. The basic method of Prahoc production is a salting process with two steps. The first salting step takes one day to drain out wild water from fish meat. In this step, the amount of salt is 100 gram per kilogram of fish. After draining, the fish are stuffed in the salting cup/tank. By the end of the process, the fish are filled with brine, ground salt remaining at the bottom and the top covering the fish to avoid exposing the fish to the air. Fermentation is performed by mixing the fish and salt thoroughly. Total amount of salt used is 30-35% of fish weight.

Modern processing technique

First, the fish are beheaded, scaled, eviscerated, rinsed well in fresh water, and screened by machine. After that fish are ripened for 8-24 hours to allow it to develop its characteristic flavor, consistency and appearance. Salting process is the basic method of Prahoc production with two steps. The first salting step takes one day to drain out wild water from fish meat. In this step, the amount of salt is 100-150 kilograms per ton. After draining, the fish are arranged in the salting tank. By the end of the process, the fish are filled with brine (about 3 kilograms of salt with 20 liters of water) with ground salt remaining at the bottom and the top covering the fish to avoid exposing the fish to the air. Fermentation is accomplished by mixing the fish and salt thoroughly. Total amount of salt used is 30-40% of fish weight.

In addition, Table 7 shows comparison between traditional and modern technique and how they vary as to period of time, the quantity of Prahoc, the types of machine, and the labor for processing.

Table 7

4. Discussions

4.1 Prahoc production

In this present study, the methods of Prahoc production are different according to locality and tradition. For the production of prahoc in Phnom Penh and Kandal province, the fish used are fresh. Fish was beheaded by machine in large-, medium- and small-scales. The micro-scale used knife for beheading. After beheading fish is washed and screened. Then kept for ripening for 12-24 hours and mixed with salt (one kilogram of salt for three kilograms of fish) and stored for 24 hours for salty fish to be drained of wild water. After 12-24 hours, the salted fish is removed for storage in jar or tank. The salted fish is stored in the jar or tank for over three months and it becomes fermented fish paste or the final product Prahoc. In the Prahoc production in Kampong Chhnang province, the fish goes through a beheading machine for removal of scales, guts, and gills. After beheading, fish are washed in river and screened. Then it is mixed with salt ratio of 1:5 and stored for selling to middlemen or retailers or processing in other provinces. This prohoc can be called "salty fish" or "semi-production of prohoc". For the Prahoc production in Battambang province, the first producers bought salty fish, mixing with salt again, keeping for ripening 12-24 hours for the draining of blood and wild fish. The salty fish is stored in a vat/jar/tank. After storage, producers sell prohoc to retailers or keep it for sale themselves. In Siem Riep province, there are two kinds of Prahoc production including Prahoc Sach (Fish paste without bone) and Prahoc Cha-eung (Fish paste with bone). For Prahoc Sach, fresh fish are taken, scraped of their scales and cleaned. After that, fish was soaked in water for the fish to harden, and then sliced by knife. Fish slices are washed to remove fish blood, kept for swelling for 12 to 24 hours to remove fish blood and wild water, water drained and then dried for a moment. Then fish was mixed with salt in 1:5 (one time of salt and five times of fish) and ripening for 12-24 hours. The salty fish dries for 1-3 days depending on sunlight. After sun-drying, it is kept to ferment for over three months, then pounding salty fish and brine until fish slice and salt are exhausted. The exhausted fish slice is stored in jars or vats for when the retailers or middlemen need to sell or when vendors order. This process is similar to that described by Ynizal (1998) in processing of fish paste with salt only. First, *rebon* fish is washed, drained and fried, until half-dried. During drying, impurities, such as small fish, mussel shells and coral, are removed. After that, semi-dried *rebon* is sifted to separate sand and other undesirable materials. The *rebon* is then left overnight at ambient temperature and pounded the next day. During the first pounding, salt is added (around half of the total salt required during processing). Total amount of salt used in fish paste processing is 2-5% of *rebon* weight which should be added as solution. Pounded *rebon* is sun-dried and subsequently kept in a container at ambient temperature for 2-3 days. The stored *rebon* is then pounded for a second time, while the remaining salt is added. After that, the pounded *rebon* is sun-dried and kept at ambient temperature for 2-3 days until soft. It is then ground by many passes through a meat grinder until fine. Fine *rebon* is formed in cubes or cylinders of 1 kg weight and subsequently fermented for a week or more at ambient temperature.

On the other hand, Prahoc cha-eung producers bought salty fish from other places such Kampong Chhnang and in the river basin. Salty fish was bought from beheaders and mixed with salt again, kept for 12-24 hours, stored over three months so that the salty fish becomes prohoc. According to Bunhak, et al. (2003), these are salted and fermented products from small- to medium-size fish. Production methods vary according to locality and tradition. For fermentation, the fish is dressed, possibly headed, and partly or wholly eviscerated and mixed with salt. After a few days, further treatment like filleting and packaging might be done. In order to increase shelf life, sometimes carbon hydrate or salt

are added to lower the pH. Main production areas in Cambodia are the banks of Tonle Sap River. According to Dara and Saroeun (2006), they reported that fresh fish 10 Kg used salt gain grind 3 kg in fish processing and weight of fish processing remain 5 Kg for fish paste with bone and 7 kg for fish paste without bone.

Fermented fish paste is a concentrated form of fermented fish, separately itemized in some surveys. It is not paste as commonly understood, but products where fermentation has digested the fish to the point where the form of the fish is no longer discernible. Fermented fish paste is typically made from small fish such as the common small cyprinids (Cirrhinus spp.). Preprocessing varies by species, some are used whole, some are headed, and cleaned and fatty species (Cirrhinus spp. in particular) are kneaded or pounded to remove fat. Fish are mixed with salt, after some time liquid is decanted and may be used as fish sauce. The mixture is fermented, typically for three months to one year (Hortle, 2007). In Lao PDR and Thailand, a small amount of rice or rice bran may be added late in fermentation. Inland fish paste has highly variable protein contents of 7.9-24% (Phithakpol et al., 1995; and Suntornratana, 2002) also provided a figure of 24% for a fish paste from northeast Thailand. As the proportion of different quality fish pastes throughout the LMB is not known, a mid-range figure of 14% protein was assumed. This would imply a dilution during processing of 0.70 (14%/19%), which after applying the preprocessing factor gives an overall conversion factor of 1.4 (Ahmed et al., 1998) and 0.8 (Sjorslev, 2000).

4.2 Good Practice of Prahoc production

In the present study, good prahoc production is in Phnom Penh, Kandal and Siem Reap Province. In Siem Reap province, producers used traditional technique for prohoc production called Prohoc Sach that had a higher price than other provinces. Producers in Phnom Penh city and Kandal province are similar because the producers utilized techniques that utilize a machine for beheading, washing and screening. Modern or industrial producers are mostly wealthy people. By and large, they produce dried fish, steamed fish, and fish sauce. They have bigger housed, warehoused, motorbiked, and even card for transporting processed fish and distributing to the market (Dara and Saroeun, 2006).

The traditional processing technologies can be classified into three scales such as small-, middle-, and large-scale (Hap Navy, 2001). Generally most of traditional processed products are supplied for domestic consumption. In contrast, the modern processing technologies products are supplied for both domestic and export markets. The quality of fermented fish is assessed subjectively by visual and/or organoleptic inspection. The main quality parameterd are texture, color, odour and fragility (Kofi, 1992). The shelf life of fermented fish is an important quality characteristic. At high moisture content or low salt levels, insects tend to lay eggs on the product which eventually develop into maggots and destroy the fish (Kofi, 1992). The producers in this province used modern technique if compared with prohoc producers in Siem Reap who used traditional technique. Similarly to Bunhak, et al. (2003), who reported that best practices principle have six points: (1) Credibility and trustworthy relationship: even the smallest entrepreneur feels that someone who himself is running a company, or is part of one, can give better advise about business development than a government employee who only knows the business environment in theory. In addition, often business-sensitive data are dealt with when it comes to analyzing and optimizing business processes. Even in developed countries a situation where an employee of the government, which collects tax and fees, advising a company on business

internal matters is extremely uncommon; (2) Expertise: An expert-employee of a BDS provider from the private sector is likely to be an expert in his field; if not yet, he will become one. Expertise is also one of the key comparative advantages and thus an asset of a BDS provider so, very likely, there is an organizational interest to further develop and keep expertise where it is needed; (3) Profit ensures sustainability: BDS providers who make profit stay in business and continue to provide services; (4) Competition leads to better quality: Ultimately there will be a variety of BDS providers competing for the same clients. This competition will increase the quality of BDS provision by individual providers or sanction the ones that provide bad quality services; (5) Strengthening the private sector: Supporting private BDS providers mean support the establishment or development of private enterprises in another sectors; and (6) Absence of misguided technology dissemination programs: In many cases, public sector programs for promoting mechanization or agro-industries have resulted in an attitude of "we know best what is good for the farmers" and in the implementation of centrally-planned machinery dissemination programs. All those programs known to the author from the region ended up in complete failure leaving machines and tools rotting away unused because they were not suitable for the agro-ecological conditions or are just not economical under the local conditions. Instead, being interested in good customer relationships and in their reputation, they will likely advise their clients properly on what technology to choose. In contrast, these practices relate to dressing, washing, salting/fermentation, drying, and waste disposal of the fish, as well as the use of poor quality salt and curing containers. It was certain processing practices constitute health hazards to consumers, producers and the environment (Kofi, 1992).

4.3 Problems relating to Prahoc production

In the present study, producers encountered some problems such as high price of salt, price competition for fresh fish, unclean beheaded fish, rancidness, low price of Prahoc, authorities taking money from producers, lack of capital to turn over, salting is not good in the river, difficulty to determine market price of final production, addible water before weight, and the company blends the price of SSF. Liu (1996) identified the following problems and constraints that hinder the development of agro-industries: absence of entrepreneurship, lack of credit, government intervention, underdeveloped market, lack of qualified labor, and technology problems. Similarly, the following are the constraints for micro- and small-enterprise development in Cambodia presented in ILO report on micro- and small-enterprise development for poverty alleviation in Cambodia, 2000: low income and purchasing power, poor national and local roads, competition from imports and poor product quality, lack of good information on domestic and foreign markets and on domestic and foreign sources of technology and equipment, shortage of working capital and low household propensities to save, high cost and limited availability of power, high informal road taxes, and low level of education and technical skills. According to Paris (2002), the following constraints exist for the agro-industry in Cambodia: lack of knowledge of simple processing techniques for easy and cheap processing of agricultural commodities; non-existing reasonable grading and packaging material; lack of transportation means and infrastructures accessing rural areas in all seasons; lack of market information and quality control causing the large gap between the farm-gate prices and terminal market prices; non-existing of wholesale markets and distribution centers for the agricultural products; and lack of micro-financial credit for developing agro-processing activities. Producers are sole owners, rarely registered, and do not rely on any credit or investment capital. Micro agro-processing enterprises are typically occupying only 1-2 family members. This present study, similar to Lytour (2003), found that the weakness of

fish processing is high cost of water and electricity; poor support industries: packaging materials and processing machinery; lack of quality control; lack of good information on domestic and foreign markets and on domestic and foreign sources of technology and equipment; shortage of working capital and low household propensities to save; low level of education and technical skills; high informal taxes; poor research and development infrastructure; and lack of trained human resource in agro-processing.

According to Dara and Saroeun (2006), the high price of salt was due to heavy rainfalls, flooding and low salt production. However, the price of fish remained stable and cheap, the people could not afford to process fish. It affected people's livelihoods at that time, especially the poorer families in rural areas who were depending on fish processing for main-income generation. It also affected poor families who are always processing fermented fish for whole-year consumption especially during farming season.

4.4 Economic analysis

Micro-scale Prahoc production in Phnom Penh city, Kandal, Kampong Chhnang, and Battambang provinces was not profitable. The exception were producers in Siem Reap who got profits because of the price, kinds of Prahoc (boneless), and quality. Producers made Prahoc for their own consumption because they thought that Prahoc in the markets is not good to eat because some producers used chemical to prolong shelf life and there is no sanitation during processing. These points made family-scale or micro-scale produced Prahoc for their own use during busy seasons or in soup. When family-scale and self-produced, it is free of chemicals and is hygienic.

According to Dara and Saroeun (2006), two kilograms of fresh fish can produce the final product of 1 kg of bony Prahoc, and 1 kilogram of boneless Prahoc is made from 3 kg of fresh fish. One kilogram of fresh small fish could be sold to producers very cheaply at Riel500-1,000, salt at Riel500iel, and labor input at Riel100-200 riel of fresh fish to be processed. At that time, the price of 1 kg of bony Prahoc was about Riel2,500 and 1 kg of boneless Prahoc was Riel5,000.

On the other hand, small-, medium- and large-scales productions are profitable in the provinces along Tonle Sap great lake and Basin River. According to small-scale fish producers, they mostly can process dried fish, salted fish, and some kind fermented fish of around 15-30 kg and get daily income at about Riel7000-15000. The earned money is spent on food, clothes, children's education, and so on. For small-scale fish producers, most workers are poor women and children, who are neighbors of producers in the village. For laborers working with family-scale and medium-scale fish producers, they are paid daily based on the amount of fish processed. They normally can earn around Riel3000-5000 per day. Payment is based on the outcome of work (Dara and Saroeun, 2006).

Fish paste producers reported that fish for producing fish paste has decreased sharply in quantity, compared to prior to the reforms. The fish price has increased from Riel350-500 to Riel800 -1500 per kg after reforms and salt has also increased in price. Prahoc sold for Riel5000-12000 to several provinces.

Small and medium enterprises have been considered by scholars to have an important role in economic growth, employment-generation and income-generation. In East Asia particularly, Harvie and Lee (2002) claimed that SMEs have played and are increasingly playing an important role in economy development. According to Iqbal and Urata (2002)

in Japan, SMEs have played a significant role in keeping their share of employment fairly stable during the bubble economy. While in Korea, the role of SMEs has experienced a dramatic transformation in the last 25 years, and they have been important generators of income and employment despite the general perception that Korea's economy is heavily dominated by large conglomerates. Like Korea, Taiwan's SMEs shared substantially in the country's rapid economic growth of the past quarter century (Iqbal, and Urat, 2002). In Indonesia, the contribution of SMEs to the Indonesian economy in terms of employment generation is significant (Mitsuhiro, 2003).

5. Conclusions

Most producers in the province used traditional technique as the method to produce fermented fish paste in Cambodia. Also, modern technique is used for fermented fish paste production. In Phnom Penh city and Kandal province, existing Prahoc production are similar: fish selection, beheading, washing, screening, ripening, mixing with salt, fish fermentation, adding a little of salt, storage in jar or tank for three months. In Kampong Chhnang, Prahoc production includes fish selection, beheading, washing, screening, fish mixing and storage in jar or tank or boat according to place of producers. Prahoc production in Battambang province was a process continuing from Kampong Chhnang province. The processing was as follows: producers bought salty fish from middleman or producers in River Lake. Prahoc production in Battambang province is selection of salty fish, mixing with salt again, ripening for 12-24 hours, storage in jar or vat or tank according to available equipment or materials. In Siem Reap province, there are two kinds of Prahoc production: Prahoc Cha-eung and Prahoc Sach. The processing of Prahoc Cha-eung is the same as Prahoc production in Battambang province. On the other hand, Prahoc Sach is the traditional processing in this province: fish selection, washing, slicing, ripening for 12-24 hours or overnight, washing fish again, mixing with salt again, keeping or storing overnight, sun-drying for 1-3 days, pounding salty fish, storage in vat for three months and getting final production or fermented fish paste (Prahoc).

Good Prahoc production practice is in Siem Reap, Kandal province and Phnom Penh city. Prahoc Sach in Siem Reap is the best Prahoc in Cambodia. This province made Prahoc by traditional methodologies because producers used knife for slicing fish and pounding with salt brine. On the other hand, processing in Phnom Penh and Kandal province is good Prahoc production, but the processing is modern technique because producers utilized machine for beheading, washing, and screening fish. To sum up, producers in Kandal province and Phnom Penh city used the labor force for mixing salt and the machine for beheading, washing and screening fish. In contrast, Prahoc production in Kampong Chhnang and Battambang province are not so good because producers did not drain water in the fish and ripening fish before it becomes salty fish. When producers did not drain wild water out and ripen fish before mixing with salt, it made Prahoc production become rancid.

In Prahoc production in the province along the Tonle Sap great lake and Basin River, there are some problems encountered by the Prahoc producers such as high price of salt, price competition, unclean beheaded fish, rancidness, low price of Prahoc, police taking money, lack of capital turnover, salting is not good in the river, difficulty to determine market price of final production, addible water before weight, and the company blends the price of SSF as revealed by respondents. Most of the producers have a large household size and in

essence, involving them in family labor, thereby increasing their production and profit at the end of the whole processing activity.

Micro-scale of Prahoc production in Phnom Penh city, Kandal, Kampong Chhnang, and Battambang provinces yielded negative profit. The exception were producers in Siem Reap who got suitable profit because of the price, kinds of Prahoc (boneless), and quality. On the other hand, small-, medium- and large-scales got suitable profit for running business. In conclusion, this study indicates that Prahoc production may be profitable.

Based on the result obtained in the study, the following recommendations were made: 1) There is a need for community-based programs towards ensuring the availability of raw materials; 2) Improved processing technologies should be embarked upon by providing the producers with training either by government or some concerned Non-Governmental Organizations; and 3) increased shelf life and improvement of presentation of fish paste.

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