Quality Assurance Program for Frozen Surimi in Thailand

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Abstract

Frozen surimi has been a major export fishery product of Thailand for many years. Approximately 70% of its total production is exported to Japan, while the remaining is locally used and exported to France, Korea, Taiwan and Singapore. Although surimi is not categorized as a high risk item, as it is not a ready-to-consume product but prepared to serve as a raw material for a variety of surimi-based products, it still needs to meet the minimum requirements of product safety control. In this study, the quality assurance program is established for the Thai surimi industry. The guidelines are prepared and based upon risk assessment and potential health hazard identification associated with routine surimi production, from the point where raw material is received at the plant, through the line-processing steps, and ending with the finished product's transportation. Besides the Hazard Analysis and Critical Control Point (HACCP) principles applied in this program, Good Manufacturing Practices and sanitation standard operating program are also added to strengthen the aim of assurance in food safety.

Introduction

Frozen surimi is minced fish which is washed with water and mixed with cryoprotectants to prevent the product from denaturation during frozen storage (Suzuki, 1981). Surimi was originally developed and has been produced extensively in Japan to serve local consumers. The processing technology was first transferred to the Thai seafood industry in late 1970s when it was found that certain fish species abundant in Thai waters have good characteristics required in surimi. Frozen surimi was then developed into a major fishery export product of Thailand. Fish normally used are threadfin bream (*Nemipterus* spp.), croaker (*Otolithes* spp.) and purple-spotted bigeye (*Priacanthus tayenus*). Other fish like largehead hairtail (*Trichiurus lepterus*) and lizardfish (*Saurida* spp.) are sometines used, as their total landing is still small and insufficient for mass production.

Like any other fishery product, the processing lines could be exposed to a number of potential contamination sources, including sources such as human, equipment, machinery, or even the raw material itself. These contamination may lead to the loss of product safety and might eventually threaten consumer health. Although the intended use of surimi is to be further processed, and the process will undergo heat treatment, the presence of *Salmonella* or metal chips detected from surimi blocks are still not favourable to buyers and could cause rejection by authorities. Whenever these are present, this also reflects lack of food hygiene and safety control in processing lines.

Therefore, the implementation of a good quality assurance program including the standard of sanitation and methods of operation in the processing plant will impact on quality and safety. To ensure consistency of product quality, this program will be more effective than end-product inspection.

This paper discusses the application of a quality assurance program for frozen surimi, particularly in Thailand, and also covers the overall good manufacturing practice (GMP) and sanitation control that should be carried out, and finally conclude with implementation of Hazard Analysis and Critical Control Point (HACCP).

Materials And Methods

Five surimi processing plants; three from the Central region and two from the South, with production capacity ranging from 5 to 70 tonnes per day were selected for this study. The surveillance procedures were carried out as follows:

1. Plant inspections were carried out two times (every 6 months) in 1995 and focused on the general plant sanitation and good hygienic practice. The plant inspection forms of the Department, based on the Codex's Code of Hygienic Practice and the Canadian Department of Fisheries and Ocean's inspection guides, were used. In addition, in-plant quality control reports were also reviewed.
2. Plant performances were then evaluated with the surimi processors. Discussion carried out was focused on health hazard likely to occur in

the processing lines and also dealt with problems of surimi production concerned with food safety, quality and wholesomeness.

3. Plant inspection reports which were routinely done by the Department from 1994 to-date were reviewed for deficiencies found in the past.
4. Product lots inspected by the Department which did not meet with bacterial standards were gathered to assess the efficiency of the quality control program of the establishments.

Results And Discussion

1. Frozen Surimi Process

The inspection of the five surimi processing plants confirmed that surimi is made as follows: The commercial process is carried out almost entirely mechanically, except deheading and gutting. When fresh and iced fish arrives at the processing plant, it is first visually inspected for freshness. The acceptable fish is washed in the rotary washer to remove surface contamination before deheading and gutting takes place. After deheading and gutting, dressed fish is washed again with water to remove enzymes and other contamination, then put into the meat-bone separator to separate meat from skins, bones and scales. Subsequent washing steps of mince are done in tanks with mechanically stirring paddles. Throughout, mince meat is soaked in chilled water of 5-10°C and left to settle. The supernatant is removed and the washed mince is further dewatered in a rotary sieve machine. This cycle of washing and dewatering is repeated 3 times to remove blood, fat, water-soluble protein and any remaining undesirable substances from meat (Lee, 1984). The last washing cycle is followed by straining dewatered mince in a refiner to remove the residual tiny bones and black skin. Strained, minced fish is then finally dehydrated by using a screw press.

Washing of minced meat is one of the important steps in surimi production. Removing of fat and water-soluble protein during washing will strengthen gel-forming ability of the product which is a characteristic required for production of surimi-based products (Sonu,1986). The volume of washing water is normally up to 10 times of fish weight. However, excessive washing of the meat will cause it to swell from absorbing too much water. At the last washing step, chilled water is, therefore, generally added with 0.1-0.3% salt to minimise this and to aid in the removal of water (Lee, 1984). Besides this, the pH of the water is also important to improve the dewatering performance, and suitable pH ranges suggested are between 6.5 - 7.5 (Sonu, 1986).

Finally, the dehydrated, leached mince is mixed with anti-denaturants in a silent cutter. The additives used are sucrose (8%) and polyphosphate (0.2-0.3%). The amount of additives added varies according to the types of product to be made. Sorbitol is sometimes used as an alternative to sucrose to reduce the sweet taste and delay denaturation. The ratio of sorbitol to sucrose varies on specification. For example, 4%:4% or 6%:0%, etc. The surimi with additives is packed as a 10 kg block in polyethylene bags by a filling machine, frozen in a contact freezer at -40°C for 2 hr and packed in cartons, stored in cold storage at -18°C or lower until distribution takes place.

2. Good Manufacturing Practice (GMP) for Frozen Surimi Processing

Good manufacturing practice (GMP) is a code of practice involved with hygiene requirements, as well as steps taken to control the process. Since GMP would result in product safety, wholesomeness and good quality, its practice could prevent quality problems from arising.

The results of inspection surveys conducted in the five surimi processing plants revealed the following deficiencies which may lead to problems relating to wholesomeness, quality and safety of the products.

- Uncertainty of quality of incoming fish due to improper handling, eg. rough handling, high-temperature holding, etc.
- Inadequate washing of incoming fish before moving on to the next processing step.
- Inadequate sanitation control of equipment and machinery used in some sections.
- Inadequate personnel hygiene control in deheading and gutting section.

GMP practices recommended during group discussions with lead inspectors, production and quality managers of the plants were as follows:

a. Fish receiving

The quality of the fish used in making surimi is one of the important factors in determining the quality of the finished product. It has been accepted that high quality of surimi can be obtained only from fresh and clean fish. Therefore, fish should be well iced, properly handled upon arrival; each lot of fish should be inspected to determine its condition and quality. Incoming fish should be graded according to its quality and plant specification, so that no poor-quality fish is used. Rejected or unaccepted fish should be segregated from the area to prevent the use of that fish by accident.

After quality inspection is done, accepted fish should be passed to the next processing step without delay. When fish cannot be processed straight away, a sanitary storing area should be provided. Fish should be kept chilled (0-5°C) at all times.

Incoming fish should be thoroughly washed with clean water prior to deheading and gutting. The purpose of this washing is to remove dirt, slime, scales, and reduce bacterial load on the fish. The machine should be properly designed to give an effective wash. For this wash, water with normal temperature (24-28°C) is sufficient and effective for removing contamination. But attention should be paid not to allow fish to remain in the washer too long to prevent it from losing freshness; washing machine should therefore be kept running.

b. Mince preparation (deheading, gutting and mince separating)

In this step, carefully remove all viscera and head; any remaining visceral fragments in minced meat will be difficult to remove at subsequent steps and will affect the gel-forming ability and discolour the ended product. Besides that, if fish of unacceptable or questionable quality are still found, they should be separated and discarded. Fish temperature should be kept as low as 5 - 10°C while being processed on the gutting table to retard their deterioration. Water used in contact with fish must be of approved quality and changed frequently.

The operation area and equipment used should be cleaned and disinfected frequently. All waste material is to be disposed of as soon as possible.

Before headed gutted fish is fed into the meat-bone separating machine, it should be thoroughly washed again to remove bacteria, small pieces of viscera, enzyme remaining in belly cavity and other contamination. The meat-bone separator should be equipped with chilled water spray to keep mince temperature low. This machine should be regularly adjusted so that it can do an efficient job of separating meat from other impurities. Regular cleaning and disinfecting of meat-bone separator should be carried out to remove the build up of fish parts left behind which will otherwise become a source of contamination.

c. Meat washing and dewatering

Once minced meat comes out from the meat-bone separator, it is washed immediately with chilled water (5-10°C), since an increase in temperature could cause protein to denature and accelerate bacterial growth. During settlement of minced meat, water temperature in washing tanks should be controlled at not higher than 10°C.

The rotation speed of rotary sieve and screw press should be properly adjusted to allow for efficient removal of water. All the machines used in this operation (ie. washing tank, rotary sieve, refining machine and screw press) should be made of non-corrosive and impervious material such as stainless steel, particularly where their surface are in contact with the product.

d. Mixing with anti-denaturants and panning

All ingredients used should be inspected at receipt and stored in a separate room and in sanitary conditions. Rodent control devices should be provided. Food ingredients should be stored separately from disinfectants and pesticides to prevent cross contamination.

A separate clean area is provided for mixing in the anti-denaturants so as to prevent contamination to the product. Temperature of product during mixing and forming should be controlled at not over 13°C.

e. Freezing and packing

Product should be transferred to the freezers as soon as it is prepared. Contact freezers should be capable of reducing the product core temperature to at least -18°C as fast as possible and have adequate capacity for daily production; bottle-necks should not be caused by inadequate freezer capacity.

Packing is done properly so as not to cause any contamination to product. Separate facilities are provided for the storage of cartons and polyethylene bags in order to protect them against moisture, dust or other contamination.

f. Product storage and shipping

Cold storage temperatures should be maintained at a constant -18°C in order to preserve the quality and to extend the shelf-life of the product (to maintain its gel-forming ability). However, for long-term store in cold storage, such as longer than 6 months, temperatures between -20 and -25°C are recommended.

Cartons should not be stacked against walls or directly on the floor during cold storage. Unless an adequate air space (5-10 cm) is provided between wall/floor and the product, heating of the product can occur by conduction through the cold storage wall or floor. The temperature is to be maintained at not over -18°C during transportation from the processing plants to the customers.

3. Plant sanitation control

The inspection of processing establishments confirmed that sanitation control is an important basic practice; it keeps the processing area and the environment as a whole suitable for food processing and free of potential micro-organisms which can lead to food contamination. The quality of the final product will depend not only on the quality of the raw material but also on the state of the processing plant and equipment, its sanitary condition, and the processing methods used. Therefore, the processing premises and equipment must be in a condition to enable the processing of products to meet the standard requirements. That is to say, the construction of processing plant and equipment should be made of materials of proper quality and the plant must be kept in appropriate state of repair and condition to facilitate all sanitation procedures. In addition, an appropriate sanitation program should be set up for the entire processing plant to eliminate contamination to products.

In this paper, the general plant sanitation design requirements, including plant construction, equipment, water and ice quality, sanitary facilities and personnel hygiene will not be stated in detail, since the guidelines recommended are based on internationally recognized standards which are available in publications such as the Code of Hygienic Practice, General Principle of Food Hygiene of the Codex Alimentarius Commission, 1988.

The recommended sanitation program of plant construction and equipment set up for frozen surimi processing is as shown in Table 1. It is also necessary to make sure that cleaning procedures are effective in removing food residues and dirt which may be sources of contamination; monitoring of effectiveness of maintenance and sanitation program is therefore recommended along with the program.

Table 1. Recommended sanitation program of plant construction and equipment set up for frozen surimi processing.

Items	Frequency of cleaning
I. Construction	
1. Floors and walls	
1.1 Wet areas : Fish dressing areas, surimi process areas	At end of the work day, these areas should be free from all waste. Regular hosing is required during operation.
1.2 Dry areas : Dry store, loading area	At least twice a week.
2. Ceilings, pipes over work areas, lighting structures	At least once a week: ceilings and pipes should be free of debris and dust.
3. Drains	At end of work day; drain screen should be taken off and drains should be flushed to remove debris. Waste should not be left overnight in drainage lines.
II. Equipment/machinery	
1. Bins, fish baskets	After each use.
2. Heading & gutting tables	At lunch breaks and end of work day. Hosing down is required after each load of fish on tables is finished.
3. Cutting boards	Clean at lunch breaks and end of work day; soak the boards every night in 100 ppm chlorinated water. Hosing down during operation should be made whenever dirt is present.
4. Knives	Frequently dip in 100 ppm chlorinated water when dirt is visible during work. Properly clean at lunch breaks and end of work day.
5. Fish rotary washer	At lunch breaks and end of work day. Washer should be free of scales, slime and debris after cleaning.
6. Leaching tanks	Hose down after each use. Cleaning done at lunch breaks and end of work day.
7. Meat separator, rotary screen, press	Flush with high pressure water at lunch breaks and clean at end of work day.
8. Silent cutter and equipment for filling	Clean at lunch breaks and end of work day.

4. Application of the HACCP plan for frozen surimi

The Hazard Analysis and Critical Control Point or HACCP has been broadly known as a system for control to ensure food safety and quality for consumers. The guidelines of HACCP plan for frozen surimi was based on the potential health hazards and risks to food quality which may arise throughout the processing steps. Information was gathered during plant inspections carried out by the Department (Keerativiriyaporn, *et al*, 1994-1996), and bilateral discussion between industry and the Department.

Hazard analysis and risk assessments were carried out for each processing step right from the time the raw materials come into the processing plant until the finished product was shipped out. The generic model was established by following the 7 principles of HACCP (Codex Alimentarius Committee on Food Hygiene, 1993) as follows :

- Conduct a hazard analysis. Prepare a list of steps in the process where significant hazards occur and provide the preventive measures.
- Identify the CCPs in the process by using a decision tree.
- Establish critical limits for preventive measures associated with each identified CCP.
- Establish CCP monitoring requirements, and procedures to follow up on the results of monitoring, adjust the process and maintain control.
- Establish corrective actions to be taken when monitoring indicates that there is deviation from an established critical limit.
- Establish procedures for verification that the HACCP system is working correctly.
- Establish effective record keeping procedures that document the HACCP system.

a. Hazard analysis and risk assessment

The hazard analysis and risk assessment for frozen surimi was conducted by reviewing the likelihood of occurrence of the various hazards at each activity point. Product description (Table 2), product ingredients and incoming materials list, and process flow diagram (Fig. 1) were the basic tools used in this assessment. Three major categories of hazards - biological, chemical and physical - were considered. The results are shown in Table 3.

Table 2. Product description for frozen surimi.

DESCRIPTION PRODUCT

PROCESS/PRODUCT TYPE NAME : Frozen minced fish

1. Product name(s)	Frozen surimi.
2. Important product characteristics (A_w, pH, preservatives....)	Raw, minced fish which pass through leaching process, mixed with sucrose, sorbitol (optional) and polyphosphate. Moisture content 76-78%.
3. How it is to be used?	Used as a semi-processed raw material for surimi-based products.
4. Packaging	Polyethylene bag.
5. Shelf life	1 year at -18°C or lower.
6. Where will it be sold?	Processing factory.
7. Labeling instructions	Keep frozen at -18°C or lower. No rough handling.
8. Special distribution control	Keep frozen at -18°C or lower at all times. No physical damage.

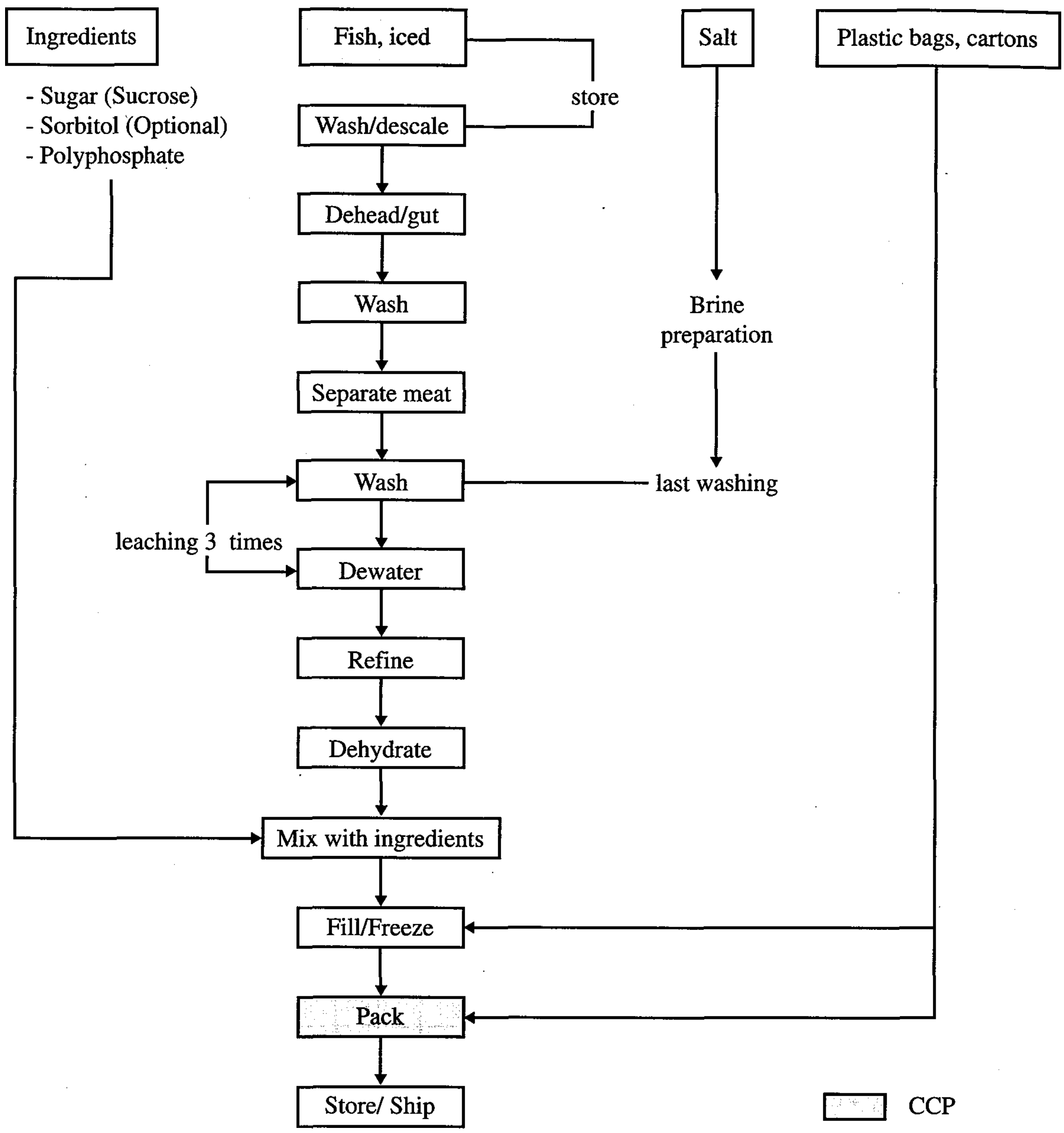

Fig. 1. Flow process diagram of frozen surimi.

Table 3. Results of a hazard analysis and risk assessment

Process step	Hazard concern	R	S	Preventive measures
A. Raw material				
1. Ingredients at arrival - Sugar - Sorbitol - Polyphosphate - Salt	1. Ingredients might contain chemical impurities. 2. Dust, foreign matters which contaminate ingredients. 3. Salt could be contaminated with halophilic bacteria.	L L L	L L L	1. Purchasing specification; certification of quality of incoming ingredients. 2. Purchasing from approved companies.
2. Fish at arrival	1. Bacteria contamination could occur from improper handling, eg. use of unclean containers, rough handling resulting in belly burst. 2. Temperature abuse during transportation from fish landing place to processing plant, eg. fish temp higher than 5°C could accelerate decomposition from enzymes, chemical or microbilogical reaction. 3. *Salmonella* and *E.coli* could contaminate fish from persons who handle fish. 4. Decomposed incoming fish.	M M M M	M H H M	1. Personnel training in GMP; sanitation control. 2. Sensory inspection of every lot at arrival. 3. Train persons who are involved in fish handling; thoroughly wash fish upon receiving. 4. Visual inspection; segregate off-quality fish.
3. Storing fish	1. Fish temperature during storage if higher than 5°C could cause decomposition. 2. Stored in a place without proper sanitation.	M M	M M	1. GMP; strict temp. control. 2. Sanitation control.
4. Polyethylene bags, cartons at arrival	Polyethylene bags could be contaminated with other chemical substances at the manufacturing plant.	L	M	1. Purchasing specification. 2. Visual inspection of every lot at arrival.
B. Process step				
1. Washing whole fish	1. Improper changes of washing water could cause ineffective reduction of microorganism, particularly when tap water temperature is used. 2. Microorganism contamination due to the use of unsanitary equipment eg. washer, fish containers, and low quality water.	M M	H M	1. Establish frequency of changing water; water overflowing at all times; management supervision. 2. Implement sanitation program; train persons involved.

Process step	Hazard concern	R	S	Preventive measures
2. Deheading & gutting	1. *Salmonella* and *E. coli* could contaminate fish due to poor personnel hygiene practices. 2. Micro-organism contamination due to improper cleaning of equipment used during operation eg. cutting boards, knives, tables. Deheading and gutting results in the spread of blood, fish juice, guts which are favorable media for bacterial growth. 3. Gut remnants in belly cavity resulting in reduction of product gel strength due to enzymatic action.	M M L	H L M	1. Improve personnel hygiene practices; management supervision. 2. Implement cleaning program. 3. Train personnel involved; random visual inspection.
3. Meat separating	Mince could be contaminated with bacteria from an unsanitary meat separator used. A pile-up of mince in the machine for many hours could result in high bacterial load.	M	M	Implement proper cleaning program.
4. Mince washing	1. Low water quality could result in microbiological contamination. 2. Insufficiently low temperature of wash water may result in microorganism growth. 3. Brine preparation in unsanitary condition (for last washing).	L L L	M M L	1. Implement proper water treatment system including chlorine injection; check chlorine residue in water twice a day. 2. Use chilled water at 5°C; chiller maintenance. 3. Train persons involved.
5. Dewatering	A pile-up of mince around the rotary sieve for many hours would allow micro-organism growth which subsequently contaminates product.	M	M	Implement cleaning program.
6. Refining	A pile-up of mince around refiner for many hours could lead to high bacterial load which subsequently contaminates product.	M	M	Implement cleaning program.
7. Dehydrating	A pile-up of mince around screw press for many hours could lead to high bacterial load which subsequently contaminates product.	M	M	Implement cleaning program.
8. Mixing	A pile-up of mince in silent cutter and other equipment for many hours could lead to micro-organism contamination in final product.	M	M	Implement cleaning program.
9. Freezing	Temperature control during freezing, eg. temperature is not low enough or not brought down fast enough.	L	M	1. Record temperature at each use; GMP. 2. Freezer maintenance.
10.Packing	Product could contain bits of metal from processing equipment.	M	H	1. Machine maintenance. 2. Metal detecting for every block.
11.Storing & shipping	Temperature during storing and distributing may fluctuate or rise above -18 °C to cause microorganism growth and affect product gel strength.	L	M	1. Temperature recording; GMP. 2. Machine maintenance.

R = Risk S = Severity H = High M = Medium L = Low

b. Determination of critical control points

The selection of critical control points (CCPs) was based on the assessment of severity and likely occurrence of hazards and upon what could be done to eliminate, prevent or reduce the hazards at a processing step, as well as the final intended use of the product. Determination was done by using the HACCP decision tree developed by a Codex Alimentarius Working Group on HACCP in 1993. After selecting the CCP; critical limits were set; these are boundary posts by which to assess the safety of the product. Monitoring procedures to assess whether a CCP was under control are also set up, together with a corrective action plan which is activated when a deviation occurs. The final step was the establishment of a verification procedure to determine if the HACCP plan was operating properly.

The CCPs in frozen surimi production were identified from the hazards in the fish receiving and product packing steps. The generic models were as follows:

<u>Fish at arrival</u>

Hazard: Decomposition could be accelerated by enzymatic, chemical or microbilogical reactions due to temperature abuse (>5°C) during transportation from fish landing place to processing plant, particularly when these places are far from each other; or due to poor handling from the boats.

Critical limits: Fish should be received with adequate ice. Its internal temperature on arrival should be ≤5°C.

No decomposed fish is allowed to enter processing line.

A lot of fish sampled for freshness must pass the acceptable level.

Monitoring: Sufficient ice around fish is observed visually. Each lot of incoming fish is checked for internal temperature by sampling from at least 5 different spots.

5 kg of fish is sampled from each lot in sensory examination for freshness.

Corrective action: If any of the fish examined is found to have a temperature above 5°C, the lot will be accepted or rejected on the basis of the sensory evaluation. If fish is acceptable, special handling of fish must be performed, eg., bring down the temperature as fast as possible, and process it without delay.

If the acceptance number for decomposition is exceeded, the lot will be set aside for further attention. An individual check may be done depending on the defect level, eg., a defect level of >40% will result in outright rejection, while a <40% defect level will be individually checked.

Verification: 5 kg of whole round fish is sampled from deheading table twice a day for decomposition examination.

Record keeping: A fish-at-arrival record is filed.

<u>Packing</u>

Hazard: Metal contamination in product.

Critical limits: No metal is detected in blocks of product.

Monitoring: Metal detectors are calibrated daily with the standard metal chips before start-up.

Every block of frozen product is passed through metal detector before packing.

Every 2 hr, the metal detectors must be recalibrated for accuracy, and the standard metal chips are used to test that the equipment is in working order.

Corrective action: If metal chip is detected, discard the product.

If the metal detector is found to be faulty, any product which passed through since the previous metal detector check will be brought out and retested.

Verification: The metal detector is tested with the test samples twice a day.

Record keeping: Metal-check records are filed.

Conclusion

In conclusion, when a quality assurance program provides preventive measures against hazards likely to occur in a processing plant, the overall quality of product will also be much improved. There will also be less waste either from the processing lines or of finished products.

In the case of frozen surimi, hazards which could result in rejection of the product are considered to be more concerned with food quality rather than safety. For example, the hazards from decomposition of raw material impact on product gel strength. As mentioned earlier, frozen surimi is not categorized as a high risk product; however, this does not mean that good manufacturing controls could be neglected. On the other hand, its production still needs to comply with food hygiene requirements, since once it is out of control, other complications will emerge.

An effective quality assurance program for frozen surimi is not just a single control program, but acts in combination with other relevant sub-control programs. Processing GMP and plant sanitation controls are designed to work together with HACCP plans. The application of the latter plans is not aimed to replace GMP, but to help ensure food safety. GMP and plant sanitation are prerequisite requirements which should be met and be the foundation of the HACCP plans. If the prerequisite program is not adequate and effective, then the HACCP plans will be composed of more CCPs and be more difficult to implement.

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Discussion

The Seminar took note of the information that Japan is in the process of preparing the code of practice for surimi production. Once finalized, this code should be disseminated to all countries in the region.