APPROACH TO THE SAFETY OF AQUAFARMING PRODUCTS IN JAPAN

Masashi Maita
Graduate School of Marine Science and Technology
Tokyo University of Marine Science and Technology
4-5-7 Konan, Minato, Tokyo 108-8477, Japan

ABSTRACT

In recent years, various problems concerning food safety have occurred, which have led to the awareness of this issue. With respect to farmed fish, for example, a residue of antibiotics was detected in imported farmed fish, and the incident has made Japanese aquacultural producers aware of the need for safe and reliable production. What information is required by aquafarming producers to implement safe and reliable production? This article introduces how this issue has been addressed in Japan.

Key words: GAP, hazard analysis, appropriate management, traceability system, positive list system, record keeping, product standards

INTRODUCTION

Food importing countries, such as the United States, Japan and members of the European Union (EU), are all very aware of food safety. In these countries, the requirements of setting various standards regarding food safety and of introducing hygienic management systems, such as HACCP, are becoming more stringent each year. In the EU, there is a move to have an obligatory system of tracing seafood distributed within the community. It is necessary to meet the standards of importing countries when aquaculture products are exported to these areas. In the past, a hygienic management system was often required for seafood processing plants; however, such systems are now considered also necessary at the production stage of seafood (fishery, aquaculture).

In Japan, various incidents have occurred regarding food safety, such as residues of antibacterial agents in imported farmed fish (the most recent violation cases are AOZ; nitrofuran metabolite and/or leucomalachitegreen in eel and shrimp imported from China and India), the abuse of fisheries medicines and anisakid parasitism. Currently, consumers have concerns about the safety of farmed fish owing to these problems. Farmed fish buyers in Japan are now asking aquafarming producers to disclose information about their rearing practices and the rearing history of the farmed fish. Unless aquafarming producers respond to a request for information, farmed products may be excluded from the market. The Japanese consumer's psychology is such, that in cases where problems arise concerning food safety, not only will the problem-causing products be often thrown out of the market, but the harmless products will, too. It is termed harmful rumor. Now the attitude of producing safe farmed fish, as a matter of course, which makes the consumer feel safe is currently the attitude among Japanese aquafarming producers. Consumers distrust a product unless its label has descriptions of the rearing method (feeds and medicines) and rearing practices applied. Today, the attitude among Japanese aquafarming producers is to provide safe farmed fish of which consumers can be confident. As a means of addressing this issue, a system using IT is under development that will enable producers to disclose information regarding the introduction of appropriate rearing systems and rearing histories.

HACCP is well known as a food hygiene management system, and many food-processing plants have installed HACCP systems in Japan. Recently, ISO22000, which integrates ISO9000 and HACCP as an international standard for quality management system, is about to be introduced. The HACCP system has been considered for the production of farmed fish. However, several problems arise when its concept and methods are applied without modification to an aqua farm. For example; (1) Small-scale aquaculture farms find it financially impossible to invest in appropriate systems to improve their facilities and utilities; (2) It is difficult for producers to bear the expenses of monitoring Critical Control Points (CCP); (3) It is difficult to enforce and implement product recall should problems occur; and (4) It is difficult for producers to establish the organization necessary to operate the HACCP system. For this reason, the Ministry of Agriculture, Forestry and Fisheries intends to promote the introduction of Good Agricultural Practices (GAP) at the production stage of agricultural crops. GAP refers to codes of practice that take into account environmental considerations and guide cultivation management, so as to produce safe agricultural crops. In particular, they urge producers to: (1) Consider what sort of possible safety hazards could develop during production, create an administrative system for the implementation of GAP, and clarify what quantitative indexes (standards) are necessary to control the hazards; (2) Implement appropriate production control systems with a standardization of the operating procedures, which entails determining and following the operating procedures and the methods of product quality control that minimize the safety hazards; and (3) Maintain records, which involves keeping records of rearing control and hygiene control using GAP (note that using GAP in the production of agricultural and aquafaming products is almost equivalent to hazard management of human health by a Prerequisite Program (PRP) in a HACCP system or ISO22000), but, it is not necessary to establish recall program and monitoring of products, which is considered to be easy to do.

REGULATION BY POSITIVE LIST SYSTEM

“This produced farmed fish is safe” means that it has satisfied the standards of the food hygiene law and the standards advised by the Food Safety Committee (regarding risk assessments based on scientific data). Table 1 shows the food standards relevant to aquafarming products in Japan. The standard concerning residues of veterinary medicines, which is of most interest to aquafarming producers, used to state, “No remains of any residues”. However, the food hygiene law has been revised since May 2006, and a positive list system put into place. Not just veterinary medicines, but all pesticides and some dietary additives (synthesized antioxidants such as ethoxyquin) were specified in the residue standards for seafood, with result that when the amount of a substance in a seafood exceeds the limit listed in the residue standards, distribution of that seafood is prohibited. Under the previous stipulation, “No remains of any residues”, it was possible for residues to be present, but at concentrations below the detection limits of the analytical methods provided by the Ministry of Health, Labor and Welfare. Very small quantities of residues can now be detected, which was not possible before, because of the improvement of analysis methods or the development of analytical instrumentation with higher sensitivity. In this case, it means that a food product that was found to contain “no remains of residues” now has “remain of residues”, and fails to meet the standards, resulting in the prohibition of its distribution to the market. Therefore, it is more practical to take the view that the “food does not contain harmful chemicals at a dangerous level”, and employ an indicator such as “Maximum Residue Limits” (MRLs) for those chemicals. However, some substances (such as strong carcinogenic agents listed by the Food Safety Committee) are not suited to the MRLs approach as the regulations state that they must not be detected in foods.

By the enforcement of a positive list system, the residues that were exempted from the regulations (mainly pesticides) now become subject to regulation. The targeted residues number up to 799 compounds in total. Residue analysis for every suspected substance requires a tremendous expense, but in Japan, simultaneous analysis screening is used, which is able to detect approximately 200 different kinds of residues at once.

THE SAFETY OF SEAFOOD AND FOOD POISONING

It is well known that Japanese have a high risk of seafood poisoning because of their large intake of seafood, a high proportion of which is eaten unheated, such as sashimi (sliced raw fish) and sushi. In practice, health hazards that could arise with farmed fish are considered to be the five items shown in Table 2. Minimizing consumer risk is an objective for the safe production of farmed fish. So here we discuss the risk factors that can be reduced by aquafarming producers and those that cannot be reduced or managed by aquafarming producers.

Table 1. Product standards relevant to aquafarming products based on Food Sanitation Law in Japan

Microbiological criteria	Fish fillets, shucked shellfish, frozen foods (frozen fish or shellfish) intended to be consumed raw microbial count: <100,000/g product Coliform: negative *Vibrio parahaemolyticus*: <100 MPN count/g Oyster intended to be consumed raw *Vibrio parahaemolyticus*: <100 MPN/g *E. coli*: <230/100g product microbial count: <50,000/g product
Marine toxins	Globefish poison (tetrodotoxin) sea areas where fishing is permitted, and types of globefish which can be consumed, and edible parts Shellfish poison paralytic shellfish poison <4 MU/g diarrheal shellfish poison <0.5 MU/g Ciguatera poison certain types of fish are prohibited for import and domestic distribution.
Veterinary drugs residues	Foods must not include antibiotics. Fish and shellfish must also not include chemically-synthetic antimicrobials.
Environmental contaminants	PCB (polychlorinated biphenyl) Pelagic or offshore 0.5 ppm Coastal or freshwater 3 ppm Mercury Total mercury 0.4 ppm Methyl mercury 0.3 ppm Cadmium (FDA) Crustacean 3 ppm

Table 2. Potential hazards in aquafarming

Biological	Pathogenic bacteria Virus Parasites
Chemical	Aquaculture drug residues Chemical contaminants Pesticides Natural toxins Decomposition associated with histamine formation Allergens (some foods, sulfite, etc.) Unapproved use of food additives and colors
Physical	Metal and glass fragments

The food poisoning caused by the consumption of seafood is mainly: bacterial food poisoning caused by *Vibrio parahaemolyticus*; chemical food poisoning by histamine; natural toxin food poisoning, such as that caused by puffer fish and shellfish toxins, as well as parasitic infections. Symptoms of food poisoning include stomachache, diarrhea and vomiting after a certain time since the ingestion of the causative food, the high-risk seafood stuff and the epidemiology in those food poisoning. Therefore, proper temperature control, hygienic handling as well as compliance with the regulations can avoid most of these instances of food poisoning from seafood.

Bacterial food poisoning is caused by poor temperature control or product handling during the distribution process. During aquaculture, the edible parts are not contaminated with pathogenic bacteria as these attach only to the surface of the fish. Because it is impossible to prevent the attachment of the bacteria, appropriate handling is required during the harvest and shipment operations. This will be described later.

The risk of natural toxin food poisoning (from puffer fish or shellfish toxins) cannot be managed through controls on rearing used by the aquafarming producers. Therefore, it has to be managed with strict regulations based on legislation or the ordinances issued by local governments.

"Zoonotic bioagents" refers to organisms that are pathogenic for both fish and humans. It is considered that such zoonotic bioagents rarely occur at present, because the pathogenic organisms can multiply only at low temperatures, and almost stop growing at temperatures over 30 ^{o}C. Even if fish infected with the pathogenic organism are eaten, the pathogens apparently would not grow inside the human body. For this reason, there are minimal risks of contamination from zoonotic bioagents. Those parasitic diseases caused by eating raw fish are limited to pathogens in which humans act as the final host and fish as an alternative host. There have been no reports of a parasite being found from farmed fish, even in fish species that serve as alternative hosts. This is because farmed fish do not have access to the intermediate hosts, such as phytoplankton, some snails (pond snail, melanian snail), resulting in no chance of the parasites being transferred via the food chain. However, anisakid parasites were detected from farmed amberjack grown from a young fish that had been imported from China. This probably resulted from raw fish being fed to young amberjack at the production stage in China. Since compound diet or frozen fish that can eliminate the risk of parasite infection is fed to farmed amberjack in Japan, this problem is not likely to ever happen here.

The important point regarding biological hazards is that we can not deny the possibility that pollution by human or livestock feces, containing coliform bacteria, salmonella or norovirus, leads to the accumulation of these pathogens in farmed products through the contamination of aquaculture site. Especially in the aquaculture of shellfish and prawn, it is necessary to consider the accumulation of these pathogens in their mid-gut organs. Western society takes the view that there are potential hygienic problems with using the feces of humans or livestock as a fertilizer to grow phytoplankton, for the production of seafood.

The most important food safety issue to be addressed is the presence of harmful chemical compounds, such as antibiotics, pesticides, heavy metals and dioxin, regardless of whether these directly damage human health or not. In cases of poisoning by these chemicals, which is different to the food poisoning described above, recognizable symptoms do not appear immediately, but do produce an increasing feeling of unease. Pesticides, heavy metals and dioxin are associated with polluted rearing environments and aquaculture feeds, which are hazards that cannot be managed directly by aquafarming producers. However, aquafarming producers can attempt to reduce the risk by choosing safe farming environments and feeds. On the other hand, antibiotic residues are a hazard that can be managed by an aquafarming producer through the appropriate use of veterinary medicines and a healthy rearing program. Therefore, at present, contamination with these harmful chemicals is driving aquafarming managers to adopt appropriate management systems.

SAFETY OF FARMED FISH AND THE USE OF AQUACULTURE DRUGS

It is inevitable that aquaculture drugs will continue to be used for farmed fish production. It is essential to use approved fisheries medicine appropriately, by following the instructions of usage. An approved medicine is supported by existing data regarding its safety and persistence for farmed fish. Strict adherence to the recommended withdrawal period of the medicine will significantly lower the possibility of its persistence. Inspections of illegally imported seafood reveal that harvest before the end of a medicine's withdrawal period, is the most common reason for the detection of antibiotics or synthetic antibacterial agents.

The "clearance time" is the time required for non-detection of a medicine from all organs of fish that had received the medicine. The withdrawal period of a medicine is specified to be three to five times the clearance time in Japan. This means there is a low possibility of residues if the withdrawal period of a medicine is observed, even if there are other factors extending the clearance time, for instance, accidental administration of a double dosage, or dosage at lower water temperature, which should not be regarded as problems to harvest before the medicine's withdrawal period. Notwithstanding, some fish ingest many doses and others fewer doses when a medicine is administered orally to fish kept in pond or cage by the hundreds in aquafarming, leading to individual differences in the levels of residues. That is why it is essential to strictly enforce the withdrawal period of a medicine.

Currently, a residue test is often required as evidence of the safety of farmed fish. It appears very persuasive because it shows either a positive or negative result for residues in an analyzed sample. However, if a couple of fish is analyzed and tested negative for residues, is it true to say that a whole consignment, of hundreds of fish, is safe? As mentioned above, there are individual differences in the residue levels of medicine. The safety of the entire fish consignment can be verified statistically if tens of samples pass the residue test. However, in reality, residue tests are performed on two to three samples owing to the cost of the analysis. In view of this, it is appropriate that the safety of a consignment should be maximized by the strict adherence of the medicine's withdrawal period, or by the provision of proof that no medicine had been administered for (more than) 40 to 60 days before harvest (because the longer the period without dosage before harvest, the less the risk of medicine residues being present).

Is there a possibility that a residue could be found even though an approved fishery medicine is used appropriately following the usage directions? Many instances of residue detection can be attributed to errors of usage or ignorance of required practice. For violation cases of imported seafood, such as the example described earlier, reasons for the presence of the medicine's residue include: fish for export being mixed with fish for domestic usage that are not controlled drug residues, ignorance of medicine's withdrawal period, no implementation of a residue test, keeping treated fish with fish for shipment temporarily in the same pond, technical problem with residue analysis, medicine-added feed being mixed with normal feed, and the wrong group of fish being given the medicine. To some people, the problem of medicine residues is unthinkable in Japan; however, who could say positively that it has never happened? The GAP approach ensures undertaking a measure or management practice to prevent possible problems that might lead to medicine residues. For example, GAP stipulates that producers must make and execute a rule saying "distinguish groups of fish which should be given medicine, or medicine-added feed and containers for the bait by visual methods (such as placing a sign saying 'under medication' in aquaculture ponds, or labeling with a red tape on the container of medicine-added feed)".

SAFETY OF FARMED FISH AND THE REARING ENVIRONMENT

A water quality standard for fisheries farming has been defined with respect to the rearing environment in Japan. Some standards are shown in Table 3. The standards regarding harmful chemicals were determined in relation to general environmental standards.

They are strict to take into consideration the possibility of the accumulation of harmful chemicals

Table 3. Water quality criteria set in Japan

Deleterious substance	Environmental criteria	Aquafarming site
COD/BOD (mg/L)	2	1
Coliform bacteria (MPN/100ml)	1000	1000
PCBs	Undetected	Undetected
TBT (ug/L)	Undetected	0.002
Total Mercury (mg/L)	0.005	0.0001
Alkyl Mercury (mg/L)	Below Detection Limit	Below Detection Limit
Arsenic (mg/L)	0.01	0.01
Cadmium (mg/L)	0.01	0.0001
Cyanogens (mg/L)	Below Detection Limit	Below Detection Limit
Lead (mg/L)	0.01	0.003

Extracts from water quality criteria set for fisheries (JFRCA 1995) in farmed fish. If the water quality of an aquaculture farm is satisfactory, the product growing in the farm can be regarded as safe. However, the risk of pollution by pesticides would be increased, even though water quality is acceptable, by factors such as heavy rain. Heavy rains can wash pesticides sprayed on the land to the coastal region, as evidenced by the great number of fish dying in a river after heavy rains. Therefore, it is necessary to be mindful of the effects of natural phenomenon affecting the environment.

THE SAFETY OF FARMED FISH AND AQUACULTURE FEED

Where does harmful substances come from? The most common cause is probably the feed given to farmed fish. The route with the highest risk of introduction harmful substances is via food chains.

Reasonably high-yield coastal fish groups, such as anchovy, were often used as bait for farmed fish; however, the amount of compound diet used has increased over time because of a decrease in the amount of the fishery yield by 100-percent Compound diet is used for all freshwater fish, such as rainbow trout, Japanese trout and eel. With respect to saltwater-farmed fish such as yellowtail, amberjack, red sea bream and puffer fish, the proportion of compound diet used is steadily increasing. The amount of harmful substances in feed is regulated under the “Feed Safety Law (a law concerning safety assurance and quality improvement of feed)” in Japan. The standards are defined for some harmful substances. Since compound diet are produced under the manufacturer’s responsibility and controlled by the “Feed Safety Law”, there are few possibilities for the distribution of the compound diet containing harmful substances or antibiotics.

Histamine is one of the harmful chemical substances that is considered as a risk because it causes allergic reactions. If histamine-containing fish meal is absorbed by farmed fish, and the histamine could be accumulated in the fish’s edible parts, it’s levels must be controlled to assure human health and minimize risk. Therefore, experiments were conducted by the author to examine how much histamine was accumulated in yellowtail given a feed containing histamine. Even if a feed containing a maximum of 1,507 ppm histamine was given to the fish, the amount of histamine in the meat was less than the 5 ppm detection limit, suggesting there was no histamine transition from feed to farmed fish.

In addition to this, there is also a risk associated with using a compound diet containing transgenic crops (soy bean or corn) as ingredients. If the safety of the transgenic crop has been confirmed (i.e., the national guidelines were followed) and the crops were approved in the production of the feed, it is considered not to cause any problem. On the other hand, there is a report suggesting that the transgenic gene of a crops used in a feed was detected in the muscle of fish, which may require further investigation and research. However, at present, there are no restrictions on the usage of transgenic crops that are already approved for production in Japan as a feed ingredient.

THE GAP SYSTEM IN THE PRODUCTION OF FARM FISH

Producers should manage the following three factors appropriately at the production stage of farmed fish: (1) the usage of fishery medicines,(2) the environment of the fish farm, and (3) the feeds used. GAP is a system to establish the necessary ways and means to reduce possible human health risks, and to maintain a record of farming practices. In implementing the GAP system, we should pay attention to matching the program to each production site because there is no point in having a program that is impractical or impossible to execute. The scale of the aquaculture farms is much smaller in the east and southeast Asia where there is a major regional producer, including Japan, compared to western countries. This is the main reason why it seems to be difficult to introduce the GAP system as it has been established by European countries. When hygiene control is implemented at the production stage of farmed fish, it can be performed with a high degree of control from the very beginning, like the GAP systems of Europe. However, the author has seen examples of producers abandoning the GAP system or suffering a setback midstream because of numerous requirements and the severity of standards. There are also examples where record forgery or a disregard of procedures has caused problems with the implementation of this sort of system. Therefore, it is necessary to first determine what a producer can perform at the time, and to accustom the producer to the idea of hygienic rearing practices and record entry. Then gradually the ideal rearing management system can be adopted.

The author recommends that Japanese producers begin with an inspection of their present practices and system and adopt “a checklist for introduction of the GAP system” (see Appendix 1). In this checklist, inspection items regarding rearing practices are listed from step 1 to step 3. Step 1 comprises the very least that producers should work on. After the producers have assimilated and implemented the items of the current step they are on, then they should move to the next step.

PROCEDURE FOR HYGIENIC HARVEST AND SHIPPING OPERATIONS

Harvest and shipping operations are the last process that producers should manage, and they require handling of the product with the awareness of farmed fish as a food. Concerns in harvest and shipping operations include, how hygienically the products are handled, and how to prevent the degradation of freshness and quality of the products. But having said that, the former is quite difficult to gauge. Checkpoints regarding sanitary control of harvest and shipping operations are shown in Appendix 2.

Since various bacteria are normally present in seawater and harvest and shipping operations are done outdoors, it is inevitable that bacteria, including pathogenic bacteria, will be found on the surface of the fish body or its gills. However, it is considered that bacteria have no chance to enter the edible portion if fish are alive, and their body surfaces are intact. Therefore, it is important to perform the harvest and shipping operations in a manner that minimize the number of bacteria, and limits their growth to maximize the safety of farmed fish and to maintain its freshness. The items of the checklist are based on the discussion above.

A TRACEABILITY SYSTEM FOR FARMED FISH

In Japan, a system for tracing farmed fish was introduced aimed at controlling the appropriate disclosure of safety information about the process from production through to distribution, as well as information regarding distribution, in order to ensure safe customer choices and purchase. A guideline of the traceability system of farmed fish was developed in March 2006.

In the development of the traceability system for farmed fish, it is necessary to consider the following two issues. Firstly, the safety of farmed fish should be maintained. The second issue is transmitting the information so that consumers will purchase farmed fish with peace of mind. This system requires keeping records on procedures, which include anything considered to be relevant to the safety of farmed fish, and will make it possible to trace the rearing histories of each pond or tank. The system, including the proper procedures that will ensure compliance with the rules, will be developed and documented in manuals. As an example of how the rules will be used, if a fish farm operates without the following procedures, or does not maintain the necessary records, the harvest will be held until it has undergone a safety inspection/laboratory analysis. Therefore, the system is a combination of prescribed rearing practices and record keeping (based on the GAP system) and a system of tracing farmed fish.

When the system of tracing back or tracing forward production histories is introduced, it will be possible to not only obtain information to confirm the safety of a particular food. For example, when a serious infective disease occurs, the system will also be useful to predict and prevent the spread of the infection.

FUTURE ISSUES

The GAP system should be introduced to ensure the safety of farmed fish, and it should be associated with maintaining records of rearing management and history of medicine usage. Its use should make it possible to ascertain whether appropriate medicines have been used and to disclose the rearing histories to consumers. However, there have been many incidents that have thrown suspicion on the ethics of producers and have resulted in compromises of food safety, such as disguising a product’s origin, label camouflaging and the recovering of cattle ear tags used for identifications. There is also the concern as to whether the records can be trusted if they are created by the producers themselves. As described before, compliance with guidelines for the clearance/withdrawal period before harvest could be made subject to verification. Regular inspections of these verification records by someone else, therefore establishing the system of certification by a third party, should increase the credibility. In Japan, local governments draw up their regulations independently and have begun to certify producers that introduce the GAP at the production stage of farmed fish. This system is considered to be a reasonable method of certification by a third party.

An indication of "safe for human consumption" is displayed with a number indicating the appropriate residue standard based on analysis results. But before that, it is more important to show clearly how the producers ascertained and implemented rearing practices to produce safe farmed fish, what the rearing histories are of the farmed fish, and who monitored these records. Regarding the high-risk factors affecting human health, the relevant standards and methods of control are delimited by legislation and ordinances.

Of course, food safety depends on the laws and regulations being followed. A high level of compliance or strong morals are factors that cannot be quantified. To achieve these, it is necessary to educate and enlighten producers so that they have proper knowledge.

Appendix 1. A checklist for the introduction of the GAP system

[Step 1]

1) The records logged every day include: water temperature, feed amount, the composition of used feed, the number of dead fish, transfer of fish and administration of medicine.
2) Records are kept to verify purchases of aquaculture medicines and amounts left over.
3) Records are logged clearly with what medicine was administered to what pond/tank, when, and how much volume.
4) Procedures are determined to prevent any human-induced mistakes that could happen during the usage of aquaculture medicines.
5) Records are kept for each pond/tank, which make it easy to determine rearing histories of fish.

[Step 2]

1) Aquaculture farms hold analysis results or records certifying that no large livers have been found, that would have implicated exposure to domestic or wastewater, etc.
2) Information is obtained from the distributors regarding the origin of fish used as feed on the farm or origin of other ingredients including fish meal for compound diet, and kept on record.
3) Number of fish per pond/tank and average weight are regularly assessed and recorded.
4) To prevent the spreading self-pollutants, the best ways of feed preparation, feeding, and the amount of feed given are devised and documented.
5) Dead fishes are removed from the pond/tank and treated appropriately.
6) Rearing practices are devised to prevent the occurrence of disease.
7) Procedures are determined and put into practice to clean instruments and tools daily and to keep them clean.

[Step 3]

1) Procedures are determined to confirm the safety of feeds/feed mixtures, and the records are kept.
2) Procedures are determined regarding storage conditions of feeds/compound diet, and a method of preventing the degradation of feeds/feed mixtures at the time of feeding fish.
3) Monitoring of accidents that would pollute farming environments, and the details of their occurrence are kept on record.
4) Procedures are determined to mitigate any accidents that would pollute farming environments.
5) Records are kept regarding introduced seeds and seedlings.

Appendix 2. A checklist for hygienic harvest and shipment

1) Inspections are conducted to examine the cleanliness of relevant items, such as operator's clothes and gloves.
2) Inspections are conducted to examine for cleanliness of work vessels and places.
3) Work spaces are screened to prevent feces of birds and harmful animals, or dust or rubbish blown by the wind.
4) Ice cubes made of clean water are used.
5) Procedures are determined for cleaning and disinfecting knifes, containers, chopping boards that directly contact fish as required.
6) Fish for shipment are washed with clean water.
7) Procedures are determined for cooling fish as soon as possible.
8) Inspections are conducted to examine the temperatures of storage refrigerators and fish, which should be kept at less than 10°C.