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PROCESSING GUIDE FOR FISH PROCESSING PLANTS IN KENYA

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ABSTRACT

In 1929, it was first reported that *Listeria monocytogenes* could cause disease in humans. In 1980, there was an outbreak of the disease in Auckland, New Zealand resulting in 5 deaths and 22 perinatal cases. Investigators suggested that the consumption of raw seafood may have been a contributory factor. This evidence was epidemiological rather than microbiological. There are a number of different ways by which *Listeria monocytogenes* and other pathogenic organisms can enter into the seafood processing plants and contaminate fish and seafood products, the main ones being run off from agricultural farms, direct faecal contamination by animals (man inclusive), sewage and seafood contact surfaces. Quantitative ATP bioluminescence, RODAC and TVC was used to determine the cleanliness and disinfection of a seafood plant located in Reykjavik, Iceland and results compared. These methods were used to assess the amount of contaminants on the sampled seafood contact and non contact surfaces. TVC was also used to assess the bacterial load on fish and seafood products. However, there was no correlation as per the microbes between these assessment methods. These methods can, on the other hand, be rendered useful for checking cleanliness of the seafood plant facilities, decisions/issues related to hazards and regulatory pitfalls to harmonise definitions currently used so sanitation as well as process control consideration can be fully integrated into the HACCP concept. In real sense sanitation critical control points are pervasive throughout processing facility (e.g., potable water) and is not restricted to any particular processing step, while a process critical control point, on the other hand relates to a particular processing step where, at that step through a manipulation of the process, a hazard can either be eliminated, prevented or reduced to an acceptable level. Many assume that sanitation considerations are covered in good manufacturing practices and therefore should not be part of a regulatory HACCP system, but by the rule of thumb, it should be decisive to include sanitation considerations within the scope of HACCP system to ensure safe and quality seafood. The results clearly shows that quality and quality assessment are issues that are to be well addressed by inspectors and processors in the fisheries processing sector and the need for a uniform and non-erroneous assessment method is inevitable.

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1. INTRODUCTION

Lake Victoria is the second largest freshwater lake in the world, with an area of ≈68,000 km^2. The lake is relatively shallow, with a maximum depth of 84 m and approximate mean depth of 40 m. The area of the lake is divided into the national waters of the bordering countries, with Kenya owning 6%, whereas Uganda and Tanzania own 45% and 49%, respectively.

Despite all investment in the processing sector where plants have been upgraded to the standards of design and construction required by EU hygiene directive (EEC 1991), still there are plants that are processing in unhygienic conditions (See Box 2). Kenya is one of the African fishery countries that lags behind in complying with the provisions of the sanitation and phytosanitary measures (WTO 2001). The insufficient technical know-how, human resources and facilities, is a major drawback. The fisheries department needs to strengthen through training of fish quality assurance and control staff. Provision of the communication and transport facilities to enhance logistical capacity is also important to processors in gaining full benefit of fish resources, in achieving or maintaining the level of quality demanded by export markets, especially EU markets as shown in Box 1.

The future of this industry is threatened by environmental pressures on the lake, over-fishing, water hyacinth explosion, and problems of quality and access to the European market. The environmental problems that adversely affect the fishery now and in future are the rapid development around the lake shore. These developments have increased pollution through agricultural activities, sewage and industrial effluents. Deforestation of the lake margins has increased topsoil erosion and siltation, explosion of the water hyacinth has cut off sunlight and oxygen to the water below and causing difficulties for fishing and shipping, thus algae blooms occur, causing oxygen deficiency and death of fish. Thus, this project outlines some present issues on fish quality and look at how to overcome problems in the fishing industry, while focusing on the higher value fresh and frozen fillets.

Box 1: Main markets for Kenyan fish

Quote from scientific journal

Seafood International **13** (11) 3637, 39 (1998) [En]

'The market for E. African Nile perch in Europe is discussed with reference to: effects of lifting the ban on import of E. African fresh fish into the EU; prices; competition in the Nile perch distribution sector in Europe; fresh and frozen Nile perch; distribution of Nile perch in the form of fillets; the main European markets for Nile perch (Spain, followed by Italy, Germany, France and Belgium); sales in Japan and the USA; sources of Nile perch (Tanzania, Uganda and Kenya); hygiene in processing factories in the Nile perch producing countries; and Nile perch as an alternative to other white fish'.

Box 2: EU recommendations regarding hygiene in relation to HACCP concept

Quote from European Commission Final Report On A Mission To Kenya Directorate General XXIV/1525/98-MR Final

5.6 Approved Establishments on Land
The three establishments on land approved for export to the EU were visited during the mission. None of the three establishments could be said to have standards equivalent to Council Directive 91/493/EEC. In general, the main deficiencies included:
Poor structural maintenance prevented thorough cleaning in two parts
Inadequate vermin control in some places
Use of static hyper-chlorinated water
Use of hand operated suspended hoses causing some splash of exposed fillets
6. Conclusions
"Evidence of monitoring of 'Own – Checks' by local inspectors was inadequately recorded, while the frequency and procedures for inspection of establishments was generally inadequate".

Nile perch first appeared in Lake Victoria in the late 50's, and has significantly affected the ecology of the lake. In the early 80's, the catches increased substantially to the present estimate level of about 450,000 tons per annum total for the three states in 2000 (FAO/FISHSTAT 2000 estimates). Small canoes, using either paddles (oars) or outboard engine power, do most of the fishing. Fishermen typically use drift nets, which are set overnight, baited longlines (use of *Xenoclarias* as baits) and some limited use of trawl boats from the industrial vessels. The fish are landed at various landing sites on the shore or off-lying islands. Although Kenya owns the smallest part of Lake Victoria, there had been tremendous development in processing activity around 'Winam Gulf' Kisumu, counting twelve operating factories (most of them have closed down due to insanitary conditions and raw material decline). Even if the fishery can be managed effectively, there are some problems to be overcome on the processing and marketing side as per the recommendations in Box 2 above, e.g., large post harvest losses.

All in all, though the processors have been somehow successful in identifying and exploiting markets in several European countries, there have been doubts about the quality and safety of the product as seen in the contents of the previous two boxes. There is a limited use of ice by fishermen and most of the fish are iced by the trader/agent/broker or processor after purchase at the 'Banda' landing site (Abila *et al*. 1997). Conditions at the landing sites are poor, lacking potable water supply, clean auction areas and toilet facilities.

The overall objective of this project work is to develop ''processing guide'' for fish production in Kenya, stressing the improvement of the safety and quality of the product, HACCP "Hazard Analysis Critical Control Point" and GMP "Good Manufacturing Practice" (handling, transport, time – temperature) and to generate information on the incidence of pathogens on fresh fish, (seafood product), different locations of processing facilities, and environment. The guide aims at making systematic procedures for assessing handling of raw material, process development and hygiene conditions based on GMP and HACCP for a safe seafood product with

high quality, by carrying out research and investigations in one of the Icelandic fish processing plants. This Processing guide is designed for fish filleting industries of nile perch [*Lates niloticus*] and nile tilapia [*Oreochromis niloticus*] in Kenya. It is based upon the principles and guidelines contained in the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) and "Hazard Analysis Critical Control Point System"(HACCP). This processing guide is intended to comply with the requirements of US Food and Drug Administration, and equivalent programs, e.g. those of the Codex Alimentarius Commission (CAC), and the European Union (EU). The aspect of microbiological work is aimed at promoting fundamental hygiene and sanitation requirements of quality assurance of seafood production. Success for HACCP can only be achieved when all the plant employees receive some type of training and it will only work better when plant employees at critical control points are taught the purpose of HACCP, their responsibilities and how they will fit into the system. The aim of this project is to enlighten the processor on how to:-

a) reduce post-harvest losses by ensuring the soundness of the seafood product by looking at the hazards associated to seafood, which could be biological, e.g. microbes, chemical or toxin, or physical, e.g. ground glass, metal, wood.

b) assess the cleaning and disinfection systems in the seafood plant with the rapid bioluminescence technique (ATP) combined with a conventional microbiological method and investigating whether a correlation exists between the two methods, to gain knowledge on microbiological methodologies in Icelandic Fish Laboratory for *Listeria monocytogenes* isolation and enumeration as well as rapid technique method

c) encourage and promote proper sanitation in order to have a quality and unadulterated end product and to amplify hygiene requirements specific to nile perch (*Lates niloticus*) and nile tilapia (*Oreochromis niloticus*) fillet processing plants and handling habits of raw material that will help curtail contamination at the end of the process

d) protect the seafood against contamination (from the Banda to/within the factory and shipment) so as to meet consumer expectations and market demands by establishing preventive measures within critical limits for each control point.

All this is aimed at reducing post harvest losses and the inclusion of biological operations in the seafood processing industry that is essential for total economy of the process that will lead to improved product quality and shelf life which shall be satisfactory to consumer expectation. It will also help the industry to reappear in the global market. The fish industry is confronted with a lot of challenges of new regulations and thus there is need to develop a standard guide, easy for the processors in Kenya to understand in respect to post-harvest losses and the fundamental hygiene requirements. The EU market, where Kenya exports Nile perch and Nile tilapia is becoming more stringent regarding standards and the quality of seafood products they import. Besides the need to comply with external requirements of fish importers, improvement of fish quality also serves the interest of processor, fishermen and the nation at large. Hazard analysis critical control point methodology, therefore, shall substantially reduce the financial losses suffered by processors and fishermen, improve the economy, etc.

This project guide has some information of identifying hazards that are associated with fish and fish products. It will help the processors formulate their control strategies because the increasing use by seafood companies of internationally recognised quality systems such as ISO 9000 series requires a clear and demonstrable understanding of the process and product for the system to be credible. The project guide is also to be used to help in training some inspectors who lack sufficient training, experience and confidence in enforcement of the HACCP regulations and so is total quality management (TQM) which seeks to eliminate the problems with safety and quality at the earliest possible stage. It covers some of the safety hazards associated with fish and fish products and also focuses on the problems of handling, storage and marketing systems that lead to losses (domestic and export demands). This draft guide is to assist processors to have their own check systems for process inspection, i.e. adequate monitoring and recording of data (Garret and Huddak-Ross 1991, Huss 1992, Troller 1983).

This project guide is also a way of helping a processor in assessing the ability of a sanitiser so as to meet specific pathogen targets which would serve as a means of ultimate validation of the HACCP system (Huss 1992). The idea is that either, *Enterobactericeae* or *Listeria monocytogenes* shall be used as a process control indicator and the concept would be to set a critical limit in a HACCP system that would be handled by the processor, and essentially, it is microbiological testing as an element of HACCP system.

2. LITERATURE REVIEW

Micro-organisms are one of the primary causes of spoilage and off-flavours in fish and seafood products. The production of consistently high quality seafood product requires the implementation of a thorough cleaning and sanitizing routine that is aimed at reducing the amount of bacteria entering seafood before, during and after process. Microbiological sampling and enumeration of bacteria on seafood contact surfaces, non-contact surfaces and seafood products coupled with an auditing system (Marriot 1997, Chesworth 1997), is of vital importance for HACCP systems to evaluate and record the microbiological condition of seafood and contact surfaces. In order to have a glimpse and know without glitch that seafood is processed safely, the best indicator is the total viable bacteria count (TVC) of the seafood. Every seafood product, depending on species, has a slightly different count. However, when the total viable count starts to increase over a period of time, there must be a reason for it and it must be found. Sanitation regulations are quite specific about the use of sanitizers in seafood processing operations, but unfortunately there are essentially very few seafood studies showing their effectiveness. The derivation of a reliable procedure for cleaning and disinfection of seafood processing lines and the validation of its effectiveness is a theme of much dispute and speculation (Dunsmore *et. al*. 1980, Huss 1992, Marriot 1997).

There are factors which strongly influence the cleaning and disinfection, such as the physiological conditions, types and numbers of the organisms which contaminate the seafood environment, microbiological response to cleaning and disinfection and the type and amount of soil present (McGoldrick *et. al*. 1986). The simple small plastic plates filled with general purpose agar media in the form of direct surface plates

(RODAC), bioluminometric assay of ATP and the cotton swab methods are used to assess microbiology of the facilities in the seafood processing plant (Mossel and Corstiaensen 1983). The limitations of the impression plate techniques have been extensively emphasized (Mossel and Corstiaensen 1983), and this method though readily available to non-microbiologists, provides an indication after 24-72 hours of incubation. Getting results 24-72 hours later is rather too late to correct critical situation as per HACCP requirements. The rapid biluminometric assay of ATP is simple to perform (Sharpe et.al. 1971, Kricka et al. 1984, Langeveld and van der Waals 1988, Simpson 1989, Thompson 1989). Negative readings from the equipment indicate no contamination but positive readings with ATP indicate test surface is contaminated with micro-organisms. The positive readings can be either from both life or dead micro-organisms or any other ATP containing matter, such as seafood debris. ATP has been applied to analyse fresh fish samples (Thompson, P., 1989). To ascertain ATP bioluminesence results and not to report false results, tissue test fluid contamination is always carried out and relies on detection of traces of peptides and sugars by the use of urine analysis test strips (Mossel and Corstiaensen 1983) though its discussion is outside the scope of this guide.

2.1 Shelf-life

The shelf-life of seafood is dependent on the packaging, which must inhibit fat oxidation, dehydration, provide for less bacterial and chemical spoilage, eliminate drip loss and prevent odour permeation under normal conditions. Indications of poor quality of fish are voids, dehydration, discolouration, rancidity indicated by orange colour and some black or red spots. Fish quality is determined and controlled by species, method of harvest, handling and processing, while the chemical changes are due to enzymes which remain active, resulting in spoilage, flavour changes and occur during the first few days of cold storage before bacterial spoilage begins. Bacterial spoilage is due to surface slime, intestines, and gills that harbour the organisms, since after death the defence mechanism is lost (FAO 1994).

The fish fillet is an excellent substrate for bacterial growth, because it is lower in indigestible connective tissue, a low-acid food with neutral or a near neutral pH (6.2 and above) and a relatively high water activity (Huss 1992). Fish muscles' less connective tissue and relatively higher moisture content than red meat muscles makes it more susceptible to enzymatic autolysis and to microbial spoilage. In addition, the spoilage due to the fat (oxidative rancidity), varies considerably with species and the composition of the fish since we know that the higher the temperature the faster the spoilage bacteria growth. Bacterial contamination can be via equipment, pumps, conveyors, baskets and boxes that redistribute surface contamination. The insufficient cleaning may lead to bacterial build up which in turn may act as sources of frequent contamination (Dunsmore and Thompson 1981). Fish auction markets where fish are placed on dirty sacks, wooden, metal or plastic basins in the open can cause potential dangers of bacteria and exposure of the catches to direct sunlight permits multiplication of spoilage organisms. The delays in cooling the fish when the temperatures are high reduce shelf-life (Dunsmore and Thompson 1981, Huss 1992).

The presence of vermin, birds, animals, harvesters, auctioneers and processors are some additional sources of contamination especially during sorting, filleting, packaging, trimming and wet processing (Huss 1992). This operation can transfer

organisms that are usually associated with man directly to the fish from gutting and fish skin to the fillets. It is however estimated that fillets from processors usually have $\geq 10^3 - 10^5$ gram^{-1} bacterial organisms (Martin1994). This can be attributed to contaminated surfaces, filleting knives, the processing facilities etc. Under refrigeration the Gram negative organisms thrive as opposed to Gram positive, except for *Listeria* sp. (ICMSF 1986). *Listeria* species have been isolated from seafood since the late 80's and are considered a potential food-borne pathogen due to their psychrotrophic nature (Huss 1992). Seafood processors are formally required to validate their critical control procedures. Cleaning validation is documented proof that one can consistently clean a system or piece of equipment so that potentially contaminating residues are reduced to acceptable levels. Again, a straight forward precept but there is a tremendous amount of analytical work that goes into properly validating cleaning procedures that must be executed with adequate planning and scientific justification. While the concept is not new, many processing plants are still struggling with its development and implementation (Dunsmore and Thompson 1981).

The goal of cleaning and sanitizing of seafood processing facilities is to ensure that the products manufactured or cleaning agents used do not leave residues that will adulterate the quality or safety of the final product. Possible residual contaminants one might encounter include micro-organisms, cleaning agents, other extraneous materials which is a particular concern on lines running seafood products. Acceptable limits must be established for these materials, some of which are present at very low levels after cleaning, and analytical methods must be developed to detect them. At the time of harvest or slaughter, most fish are likely to contain contaminants. In many developing countries fish is received at the factory iced but are ungutted, unbled and are not thoroughly washed from the fish trucks, boats (canoes), auctions, etc., as is done in advanced Icelandic processing plants for cod (*Gadus morhua*), redfish species (*Sebastes marinus* and *Sebastes mentella*) and herring (*Clupea harengus*). The delayed evisceration has no advantage to processing because this depends on whether the fish were actively feeding prior to harvest (Martin 1994).

2.2 Washing of Fish and Temperature Monitoring

The fish temperature shall be used to determine handling priorities and fish shall be sorted for species and decomposing fish shall be discarded immediately which has been a big problem due to zealous agents and drivers. The temperature in the trucks fluctuates due to the long distances and unspecified times of boat landings. The fish should not be unloaded from the trucks and splashed with tap water before being transferred to the filleting table. Thus there is need for the processors to buy big fish plastic boxes or tubs and totes where fish can be emptied into and then have a steady overflow of fresh potable water for washing (Thompson 1989) before being examined to determine whether further analysis is needed.

Washing is necessary to remove contaminants from raw fish, and this leaves the surface of fish in a suitable condition for further processing. Fish should be washed as soon as possible after unloading from the trucks to remove small quantities which are contaminated from harvest areas to prevent subsequent loss of the remaining bulk from microbial growth during storage prior to processing (FAO 1998). Washing is thus a means of reducing post harvest losses, improving the economics of processing

and protecting the consumer. Sanitary cleaning of raw material saves time and money from being spent on contaminants which are later to be discarded. In processing, as in most of the seafood industry, a lot of evidence does indicate that the sanitary conditions of the plants correlates well with the microbial quality of the finished product (Dunsmore *et al*. 1980). The fillets shall be put to an individual quick freezing (IQF) freezer immediately after slaughter. The core temperature must reach -24^{o}C before glazing takes place (Hans 1992). After freezing and attaining the core temperature, the frozen fillets are to be glazed by water spraying, after which grading is to done by size. The fillets should be weighed in plastic trays according to specifications, and then shatter packed into cartons or packed into plastic envelopes and then packed into cartons.

2.3 Hazard Analysis

The hazard analysis shall be conducted by considering the risk (likelihood of occurrence) and severity of each potential seafood safety hazard. This is to be done to determine which hazard is "significant" and to be controlled by the HACCP plan as categorised in FDA methods and EU (Garret and Haddak-Ross 1991, FAO 1973). The system shall be designed to reduce, prevent or eliminate seafood safety hazards to an acceptable level that the processor shall adhere to in Kenya. Fresh fish is considered to be a possible source of biological hazards; these include spores and vegetative cells of bacterial pathogens, notably *Salmonella* and various parasitic pathogens. Water, including untreated lake-water, and ice used on the vessels and in the processing facilities, is also a source of pathogenic bacteria and parasites (Huss 1992). Due to the nature of the product and processes, pathogens are the primary biological hazards associated with fish fillets. Microbial growth and decomposition resulting from time/temperature abuse by holding the product for prolonged periods at elevated temperatures prior to receipt of the fish at the processing facility, may greatly affect the quality, safety and shelf-life of the processed fillets. Raw fish are not considered to be a source of any potentially hazardous chemicals, including heavy metals or natural toxins. Contamination of fish by agricultural pesticides derived from the harvest area has occurred once in Kenya. However, this is an insignificant hazard due to the infrequency of such an event, which mainly occurred as a result of unscrupulous fishermen. Prior to fillet processing, the fresh fish are always subjected to time/temperature abuse which may lead to microbial growth and faster rate of decomposition at a later stage (EEC 1991, FAO 1998, Gram *et al*. 1989, Ward *et al*. 1986). Fillets are held at ambient temperature, piled before weighing and freezing, so that the filleter can enter his/her daily record (Figure 1).

Although prevention of detectable decomposition is a quality control priority, this condition does not represent a significant safety hazard. Potable water is to be used to make ice, wash containers and filleting tables. Due to the use of chlorinated water in processing, the GMP, FDA regulation 21CFR113 procedures shall be followed during the processing and thus recontamination with pathogens are not likely to occur (EEC 1991).

Figure 1: Fish processors in a processing plant in Kenya; a situation for potential contamination because of time/temperature abuse of fish and seafood fillets.

The FAO report (1973) recommends that fish be cooled down to the temperature of melting ice, 0^{o}C, as quickly as possible but this is clearly not the case in Figure 1. The shelf-life of fish on ice is reduced by one day for each hour delay in icing or exposure to ambient temperature of 27^{o}C - 30^{o}C (Barile *et al*. 1985, FAO1973, Huss 1992). In-plant contamination with chemicals (e.g. cleaners, sanitizers, and lubricants) shall be minimised by following GMPs, cleaning and sanitising (SOPs). Adherence to GMPs and proper training of personnel will reduce the likelihood of physical hazards incorporated into packaging. In addition, pre requisite programs will help minimise the potential for metal hooks, hard plastic, glass, wood or other physical hazards to enter the cartons prior to sealing. In particular, the pre-requisite programs such as the Sanitation/GMP Compliance are essential for the success of the HACCP plan (Huss 1992). The advantages of HACCP include identifying and preventing hazards from contaminating seafood and the method is based on sound science. It allows for more effective and efficient government oversight. This is because of the records which allow investigators to follow how the processors are complying with seafood regulations over a period rather than how well it is doing on a given day. Its implementation places responsibility for ensuring safe seafood on processors and distributors and its guarantee provides competition among processors. The benefits of the quality systems HACCP are that if followed, manufacturing agility for improved responsiveness to consumer requirements shall increase (food safety regulation, research, surveillance and education).

2.4 Non-Seafood Objects

One of the big safety issues in seafood is the existence of a foreign body. A useful definition of a foreign body is "an object which is perceived as alien to the food". This may include items such as glass or metal which are clearly not seafood items or by-products of food processing, (e.g., struvite which is occasionally formed during fish processing) or an unwanted part of the food, such as a piece of bone found in fish fillet.

2.5 Microbial Monitoring

Microbiological tests is to enumerate and characterise the micro-organisms most important in fish and fishery products by looking at the factors that affect their growth and survival and where they are mostly likely found in the processing plant. The HACCP system is indeed of importance for monitoring the fish product production process to ensure conformance and detect the most likely contaminants and also to investigate and determine the roots of contamination and causes of fish spoilage. The system's seafood safety inspections focuses on preventing problems rather than chasing the horses after they are out of the barn and to change the basic difference in how many people view symptoms of food-borne diseases, where some societies consider diarrhoeal diseases as a natural/normal occurrence due to teething, eating spicy/hot foods, indigestion and even superstition, instead of perceiving it as a disease symptom that can be transmitted through food and food handling practice. Preservation and spoilage of fish is due to bacterial breakdown. Bacterial breakdown is very similar to the red meats and the microbial flora is similar. One spoilage characteristic found in fish and not in muscle foods is trimethylamine formation. This odoriferous amine is responsible for the fish smell associated with spoiling fish. The amount of trimethylamine formation is often used as an index of fish quality. Scombroid poisoning is another problem associated with fish in which the histidine gets converted to histamine (Ababouch 1991) which causes allergic reactions in consumers. Fish meat has high level of polyunsaturated fatty acids.

2.6 Icing

Chilling of fish immediately after harvest is a very important part of preservation, the use of ice or ice water to maintain the quality of the product until it is processed is important. Frozen storage requires low temperature -18^{o}C for extended shelf life. A host of freezing techniques are used, but rapid techniques are commonly employed. Freezing can alter protein functionality which reduces extractability and binding properties. Lipid oxidation may occur and if temperatures are not maintained (-18^{o}C) trimethylamine formation is observed. Consequently, prevention of histamine poisoning in seafood is possible by refrigerating or icing fish and by eliminating delays between fish processing steps (Ababouch 1991). Raw seafood is usually frozen for storage and distribution, but several studies have shown that *Listeria* can survive under these conditions. *Listeria* has been isolated in seafood stored at temperatures between -18^{o}C and -23^{o}C (Huss 1992).

3. HYGIENE SURVEY

3.1 Materials and methods

The microbiological surface and product sampling survey was done to discover sources of seafood contamination and also for verification of the presence of microbes on a very clean seafood processing surface after cleaning and disinfection. Microbiological surface sampling procedures permits the processor/operators to discover both the source of contamination and the magnitude entering the seafood production/processing environment. This monitoring was done for verification of the microbiological response to effectiveness of cleaning and disinfection, discovery of

seafood pathogen in the environment and sources of spoilage organisms, sanitary design and condition of seafood equipment. The study was also done to establish and verify control of environmental critical control points within the context of HACCP system. Three test methods, bioluminometric ATP determination, impression colony counts (replicate organism direct agar contact 'RODAC'), and the cotton swab test were studied in a seafood processing plant located in Reykjavik, Iceland (Vanderzant and Splittstoesser 1992, Huss 1992). The sampling sites for the environmental study on the facilities at the fish processing company were selected to include all points that could contain micro-organisms that can directly or indirectly contaminate the final product. The site selection was based on the results of the previous experiments performed at Icelandic Fisheries Laboratory, (Einarsson and Guðbjörnsdóttir 1997). Samples were taken (**a**) after cleaning and disinfection; (**b**) during process, i.e., after 8 process working hours and after 15 process working hours. Preoperative surface sampling sites from which the samples were taken and product samples are as in Table 1.

Table 1: Preoperative sampling sites and product samples

Surface sample sites		**Product samples**
1. Washing tub	10. Knife in cutting machine 2	1. Fresh fish skin
2. Grading machine	11. Slicing machine 2	2. Fresh fish flesh
3. Beheading machine roller	12.Plastic table – hand trimming	3. Fish after filleting
4. Filleting machine steel plate	13. Trimming machine steel plate	4. Fish after deskinning
5. Deskinning machine	14. Conveyor belt from IQF	5. Fish after cutting machine (1)
6. Knife of cutting machine 1	15. Conveyor belt from degrading machine	6. Fish before cutting machine (2)
7. Weighing machine		7. Fish after cutting machine (2) - a
8. Flowline trimming machine		8. Fish after cutting machine (2) - b
9. Overhead plastic drain above new cutting machine		9. Fish after weighing
		10. Fish after IQF

Dilutions were carried out whereby sterile pipettes were used to transfer 1 ml from the sample bottle into a test tube containing 9 ml Butterfield's buffer to make a 10^{-1} dilution seafood surface sample. 1 ml was transferred from 10^{-1} to a 2nd Butter field's buffer tube to make 10^{-2} dilution created. For another higher dilution, 1 ml was transferred from 10^{-2} to another 9 ml Butter field's buffer test tube creating a 10^{-3} sample dilution. The dilutions below were decided for enumeration of aerobic bacteria in seafood and the contact surface for statistical viable count. This procedure was used to 10^{-5} dilution sample as in table 2, (Vanderzant and Splittstoesser, D.F., 1992).

Table 2: Level of dilution for enumeration of aerobic bacteria in seafood (HITM 2001)

Category	CFU/Gram	Level of Dilution
Very Very clean	100 – 1,000	10^{-1} (10 to 1)
Very clean	1,000 –10,000	10^{-2} (100 to 1)
Average	10,000 – 100,000	10^{-3} (1000 to 1)
Poor	100,000 – 1,000,000	10^{-4} (10,000 to 1)
Extremely poor	1,000,000 – 10,000,000	10^{-5} (100,000 to 1)

* CFU is colony forming units

For inoculation, sterile pipettes were used to transfer 5 ml of dilution water to the sample vials containing the swabs and swirled for 10 seconds. The dilutions were then made on the petri dishes containing Iron Agar with 1% sodium chloride (NaCl) added and spread to distribute the samples evenly. The plates were then incubated at 15^{o}C for 96 hours.

3.2 Bacterial analysis

3.2.1 RODAC

Plastic plates filled with Dey-Engley (D/E) media used for neutralizing any of the germicidal chemicals likely to be encountered on seafood surfaces were prepared for impression. The 6 cm in diameter sterile plastic (replicate organism direct agar contact) plates filled with Dey-Engley (D/E) neutralizing media agar meniscus were pressed on the surface of the facilities by applying equal finger pressure on the plates. The plates were placed to plastic bags and packed in a styrofoam cooler box and transported to the laboratory. In the laboratory the plates were incubated at 22^{o}C for 72 hours.

3.2.2 Total Viable Counts (Iron Agar)

Twisted sterile non-absorbent cotton swabs moisturized in D/E neutralizing broth were used to swab an area of 50cm^2 on the facilities. The swab heads were then broken into separate sterile self closing plastic vials, then packed in a styrofoam cooler box and transported for further inoculation in the Icelandic Fisheries Laboratory. The sample of fish and seafood products was minced separately in a warring blender. Minced fish and seafood product samples of 25 g were each weighed in separate sterile stomacher disposable bags on a sensitive electronic balance. A Butterfield's buffer diluent of 225 ml were added into the bags containing the samples and then placed in the open chamber of the stomacher instrument for one minute massaging respectively. There was no contact between the instrument and the samples. During this operation micro-organisms are dislodged into the diluent for microbiological analysis as in the section below as this have shown that satisfactory results can be obtained by this method compared with conventional blending of foods. The sample mixture in the stomacher bag were transferred to petri dishes and incubated at 15^{o}C for 24 hours (Vanderzant and Splittstoesser1992, Huss 1992).

3.2.3 Listeria sp. isolation and identification

Twisted sterile non-absorbent cotton swabs moisturized in D/E neutralizing broth were used to swab an area of 50cm^2 on the facilities. The swab heads were then broken into separate self closing plastic vials and 20ml of UVM added, then packed in a styrofoam cooler box and transported for further inoculation in the Icelandic Fisheries Laboratory. Minces of 25 g of sample was put into 225 ml of UVM (University of Vermont) modified *Listeria* enrichment broth (BBL) and incubated in a stomacher bag at 30^{o}C for 24 hours. 0.1 ml from UVM was then inoculated into 10 ml of Fraser broth and incubated at 30^{o}C for 40 hours (Fraser broth constituents: UVM modified *Listeria* enrichment broth (BBL) + LiCl 3.0 gL^{-1}; acriflavin 0.012 gL^{-1}; Ferric ammonium citrate 0.5 gL^{-1}). A loopful from the black Fraser broth was streaked on Modified Oxford agar (MOX oxoid) and incubated at 35^{o}C for 48 hours. Later on the confirmation tests that included Gram staining and catalase tests were made on black colonies from MOX agar. Species identification included haemolysis on Blood agar and tested on API *Listeria* (a system for *Listeria* identification, bioMe´re'ux SA/France), (Vanderzant and Splittstoesser 1992; Huss 1992). Both environmental and product samples were tested for *Listeria* species. In the case of product samples, 25g were placed in stomacher bag and mixed with 225ml of pre-enrichment broth.

3.2.4 ATP bioluminescence

An area of 10 cm^2 was swabbed using a pre-wetted swab from the swab tube and replaced in the swab tube for testing at the Icelandic Fisheries Laboratory. A total of 15 swabs of ATP were collected placed in a plastic bag, stacked in a styrofoam ice box and transported to the Icelandic fisheries laboratory for reading. The tips were then broken off, the pre-wetted swabs were inserted into sterile cuvettes and nucleotide releasing agent released into the cuvettes and mixed for 10 seconds. The cuvettes were placed into the luminometer and the amount of light determined was expressed in relative light units (rlu).

Naturally only living cells contain ATP, so the amount of it in a sample is presumed to be proportional to biomass or viable cell numbers. The luciferin–luciferase system is the most common method used to measure ATP levels. Reduced flavin mononucleotide (FMN + $2H^+$ + $2e^-$ = $FMNH_2$), an important cellular biomolecule reacts with and oxidises long chain alphatic aldehydes (luciferins) in presence of O_2 (oxygen) catalysed by luciferase enzyme, thus excess energy (photons) is released as light. Artificially, an organic compound luciferin, when combined with cloned luciferase, Mg^{2+} ions, and ATP undergoes reaction wherein oxyluciferin, CO_2, AMP, inorganic PO_4^{3-} and photons are released as light see equation below,

$$E + LH_2 + ATP \longrightarrow E{\cdot}LH_2\,^{Mg2+} - AMP + PP,$$

$$E{\cdot}LH_2 - AMP + O_2 \longrightarrow \text{Oxyluciferin} + CO_2 + AMP + \textbf{Light}$$

Where:
E = luciferase; LH_2 = luciferin; PP = pyrophosphate
$E{\cdot}LH_2$ – AMP = enzyme bond luciferyl-aldenylate.

3.3 Result and Discussion

In this study during sampling after cleaning and disinfection, the surfaces were visually clean and tidy. Consequently, when one notices or reads that a seafood processing plant contains thousands of bacteria, reaction can be swift and critical, thus in this context the seafood industry must consider the problems that might be associated with their products, mostly micro-organisms which are germs and must be avoided. The perishability of seafood is the composition of native microbial flora, which is a water temperature influence from which fish are harvested. Since seafood is harvested with a variety of methods and gears, the initial quality and microbial load is always affected by these methods. Quality has to begin at harvesting, for abusive handling at harvest is detrimental to subsequent quality and shelf-life at the end.

As is shown in Figures 2 and 3, the area of concern with respect to microbial contamination of seafood processing is the use of wash tanks and machines such as grading, beheading, filleting, etc. Though wash tanks are effective in removing blood and physical debris, they can be a significant source of contamination. The study revealed 3.0×10^5 cfu/cm^2 on the wash tanks after 8 working hours though initially it was very clean. This is an indication that visual inspection on a seafood environmental basis should be accompanied by biological operations in seafood processing for essential total economy of the process for microbiological issues as they relate to quality and safety of seafood is extremely visible aspect of consumer and regulatory focus. As for the microbial load on the fresh fish skin, it may have been due to contamination in the harvest environment and/or dragging along the ocean bottom or during gutting, bleeding or contact with a working surface. The microbial flora increase on the seafood product as per the study is directly related to the environment of the seafood contact surfaces during processing. As shown in the Figure 3 and table of the analysis results in the Appendix Tables A-2 and A-3 respectively, the cross contamination of the seafood product is a result of heavily contaminated surfaces.

The unique nature of the seafood facilities and seafood operations shows a difficulty in maintaining extremely rigid sanitation standards. Thus, it is important to note that every stage of handling from harvest to consumption affects quality. Fishermen have to avoid abusive handling, while in processing plants, good sanitary conditions and strict temperature controls must be maintained for it takes a combined effort to provide the quality seafood consumers demand. Strains of *Listeria* species, a micro-organism that exists widely in the environment, have been found to be pathogenic to human being as well as to animal production (Vanderzant and Splittstoesser 1992, Huss 1992). *Listeria* species, unlike most other pathogens, continues to grow, albeit slowly, under refrigerated conditions (Huss 1992). However, extra ordinary handling practices and sanitation procedures are needed to prevent contamination. For details of other parameters see Appendix Tables A-4 and A -5.

Iron agar was used for determination of total viable counts and hydrogen sulphide producing organisms. On determining bacterial counts, surface plating was used on prepoured iron agar plate and incubated at 15^{o}C for 96 hours. Black colonies were as a result of bacteria capable of producing H_2S when decomposing thiosulphate and/or cysteine due to precipitation of FeS, (Vanderzant and Splittstoesser 1992). The

investigation of bacterial strains isolated from the samples shows that they can be potential seafood spoilers due to their ability of reducing the hydrogen sulphide (Huss 1992). The bacteriological production of hydrogen sulphide is thus an indication of the presence of spoilage organisms that could be a problem in chilled seafood.

Incidentally, as results shown in Table A-1, in the Appendix, after cleaning and disinfection data taken of ATP, RODAC and total viable counts, there is no clear relationship between the ATP bioluminescence measurement and the number of colony forming units on surface plates. Thus, the ATP measurements under practical conditions are not directly related to the number of viable organisms detected on the surface of the seafood facilities. This could be attributed to either amounts of ATP in organisms depends on the type and physiological conditions of the organism, or presence of ATP of other than microbiological origin. Although no relationship was indicative between the methods of determining micro-organism possible for contamination, all the methods, can reliably be used for detection and determination of effectiveness of decontamination procedures in the seafood processing industry (Huss 1992).

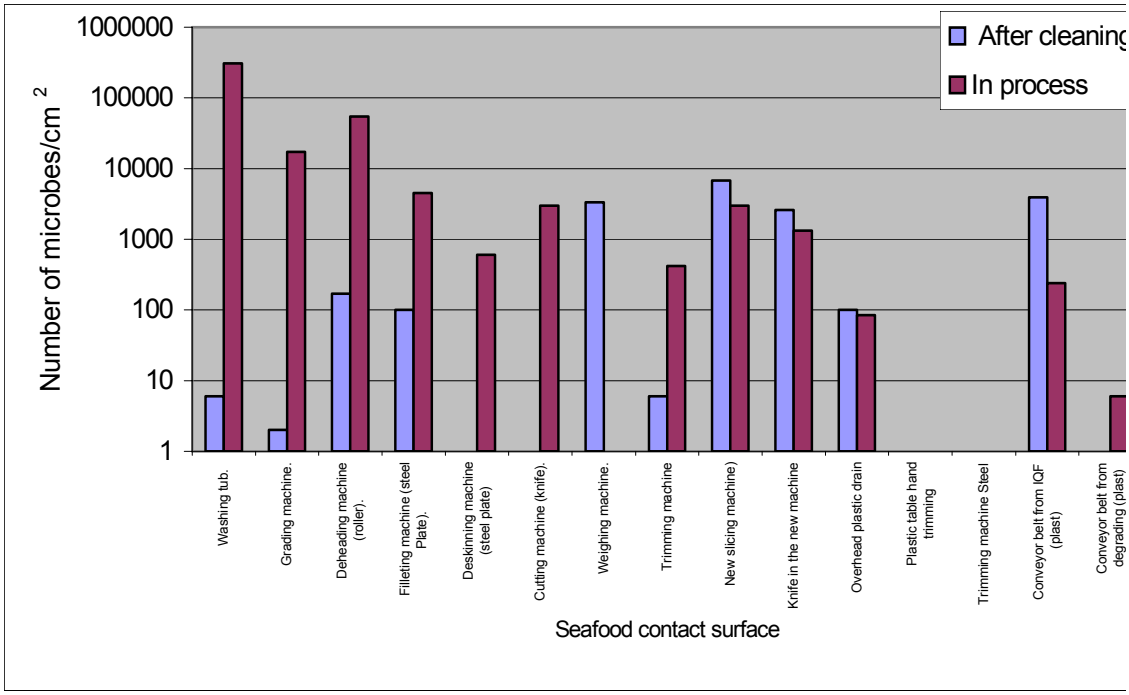

Figure 2: Distribution of microbes in the processing environment after cleaning and in processing after 8 working hrs in a fish plant located in Reykjavik, Iceland during December 2002.

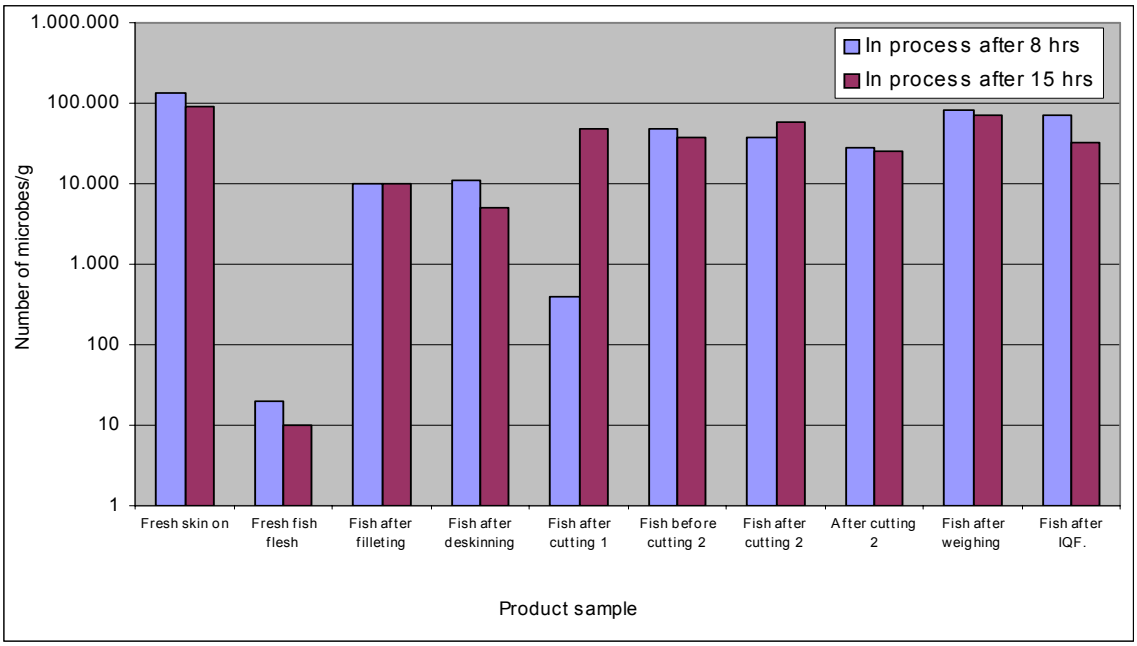

Figure 3: Distribution of microbes in fish and seafood products in a fish processing plant in Reykjavik, Iceland in December 2002.

3.3.1 Conclusion

Over time, the seafood sector has developed extensive requirements relating to hygiene of the product, thus a predictive system needs to be developed that will allow the early identification of emerging hazards, to avoid where possible. There is need for fishermen, inspectors and processors to understand the factors which impact seafood quality and make a conscientious effort to control them and the problems associated with microbial growth will be minimised to an acceptable level. HACCP system is not a plan to please processors or any government. It should be that which assure the stable operation of each process, and then, control improvement programme to assure that hazards in a seafood plant are at an acceptable level and manage the long term programme for quality improvement within the seafood processing operation sector.

3.3.2 Recommendation

Sampling and analysis helps determine the contamination concern and how to handle them. They are crucial to effective cleaning validation and monitoring, thus deserves attention that is proportional to their underestimated importance, as such to establish accountability for inspection, there is need to include microbial monitoring (coliform plates, total viable counts), environmental testing for *Listeria* species or any other related microorganisms, pre-operational ATP testing accompanied by visual inspections (organoleptic testing), tracking of chemical usage (type, concentration) and review of sanitation process. Microbiological testing is needed to monitor the proper performance of procedures and functions of an equipment, e.g. microbial load

of the conveyor belt should be known before processors embark on establishing a clean up schedule, and this should be atleast twice a month.

3.3.3 Observation

HACCP should not be used as a rubber stamp in fish processing plants nor as a static programme in the process, but rather, as a continuous quality improvement programme whereby the quality assurance or quality control department to constantly review every operation step in the facility design and validate new procedure in order to improve quality performance. A parsimonious/parlance approach to hygiene ultimately leads to disaster.

4. PROCESSING PROCEDURES

4.1 Introduction

Fish flesh is always considered sterile but there are possible sources of biological hazards like untreated water used in the processing facilities may be sources of pathogenic bacteria and parasites that affects its quality and safety. Microbial growth and decomposition resulting from time/temperature abuse prior to receipt of the fish at the processing facility, may greatly affect quality and safety of the end product. It is well documented and understood that HACCP concept is a system that does not require continuous inspections, and as such, it separates the nice from the necessary, or the essential from non-essential, and it is a system that helps prevent major errors, if properly focused as in process flow diagram (see Figure 5). However, it is not a zero defect system. Thus, this guide is intended to assist Kenyan seafood processors in developing and implementing sanitation and control procedures considerations within the HACCP concept as required by the well recognised international food laws. Seafood processors are thus requested to know how to maintain sanitary conditions and practices, to be part of HACCP regulations and decide on how to include sanitation considerations within the scope of HACCP system so as to ensure safe and quality seafood production.

4.2 Raw Material Inspection

At the time of harvest or slaughter, most fish are likely to contain contaminants and variable physical characteristics, e.g., colour, shape, size, etc. There is need for organoleptic checks. Quality of fish is to be determined by appearance, texture and odour, but fish should not be identified by colour, because colour changes due to stress, on being hooked, when removed from water, environmental changes and during spawning. Characteristics of fresh fish qualities are eyes (bright, clear and full) and as fish becomes stale, their eyes become cloudy and sunken. The gills should be red and free from slime and, but gill colour fades with age from pink to gray, brown and then green. Fresh fish odour is mild and fresh but as it ages a strong , offensive odour develops. Skin should be bright and shiny while as fish ages its colour fades and becomes less pronounced. Flesh should be firm, elastic and not separating from the bones. As fish ages, the flesh changes colour and takes on a dried out appearance.

Table **3**: Contaminants found on raw foods

Type	**Example**
Metals	Ferrous and non ferrous metals, bolts, filings, hooks, etc
Mineral	Soil, engine oil, grease , stones, etc
Plant	Roots, leaves, twigs, seeds, pods-stalons, skins, etc
Animal	Hair, bone, excreta, blood, insect larvae,
Chemical	Fertiliser, pesticide, insecticide, fumigant, etc
Microbial cells	Soft rot, fungal growth, yeasts
Microbiological products	Colours, flavours, toxins

Figure 4: Filleting processing plant in Kenya

4.3 PRODUCT PROCESSING, DESCRIPTION AND INTENDED USE

The fish fillets are made from fresh *Lates niloticus* and *Oreochromis niloticus* caught from Lake Victoria Kenya waters. The fish packs are flesh steaks, and normally does or not contain skin and are boneless. The commercial industrial processing of fish for human consumption yields are about 50% for direct human consumption. The rest 50% consisting of by-products from the process, e.g., edible heads, backbones, skin, viscera, gall-bladder and oil from *Lates niloticus* and *Oreochromis niloticus* are the only parts sold to fish fryers around the lake region. Some of the by-products are processed to pig meal and some converted to silage, but a large part is still a waste. The frozen flesh fillets are packed into cartons of 5 kg, 10 kg and 15 kg, which are then sealed, labelled and processed in chill rooms or containers. The processes are designed to produce commercially frozen safe products. The product has to be fully cooked, or heated and deep fried before serving. It is intended for export, sold to tourist hotels and the general public. The fish is filleted and skinned by hand on tables as was shown in previous Figures 1 and Figure 4 respectively, the storage temperature is one of the remedies to be looked at in the Kenyan processing plants, and as for Figure 4 splashing water from the tap can be a source of contamination. The fish fillet is trimmed on the same table of filleting and this can be a very big problem on the basis of contamination because of the water flowing from the tap which can transfer bacterial flora from the skin to the fillet as in Figure 4.

Table **4**: Seafood product description from the harvest to table

Raw material	Nile perch (Lates niloticus) and Nile tilapia (Oreochromis niloticus)
Raw material harvest area	Offshore Lake Victoria, Kenya
Raw material received	Directly from harvester or through agents/brokers transported to plant
Finished product	Fish, fillets,(fresh and frozen)
Food additives/ingredients/ processing aids	None
Packaging	Air-packaged
Storage and distribution	Stored and distributed frozen, in ice, or under refrigeration
Intended use	Fully cooked, or heated/deep fried before consumption
Intended consumers	Export and General public

Procedures for handling raw materials or packaging materials is necessary to prevent the contamination of finished products. Processing shall be carried out in a way so as to prevent the finished product from being contaminated by raw material, processing machinery, conveyors, utensils (filleting knives, crates, etc), other equipment, refuse such as fish entrails, racks, gloves and other non edible parts of the fish. Raw material and already processed seafood products shall adequately be separated during receiving and also be stored in a designated area like coolers for raw and processed products. The fillet is never checked for candling, and thus there is need for introduction of parasites check candling table. The candling table to be put in place for this matter and the illumination standards measuring 6 in. above candling table at 500 lux at a minimum and from below: 1500 lux at minimum, so that the following defects can be checked:-

Bones: all bones are to be removed from fillets

Parasites: all visible parasites are to be removed

Blood spots, bruises, scales, skin spots (except for skin on), membranes are to be removed.

Careful inspection for foreign objects, all napes to be removed, rugged edges and tail ends trimmed

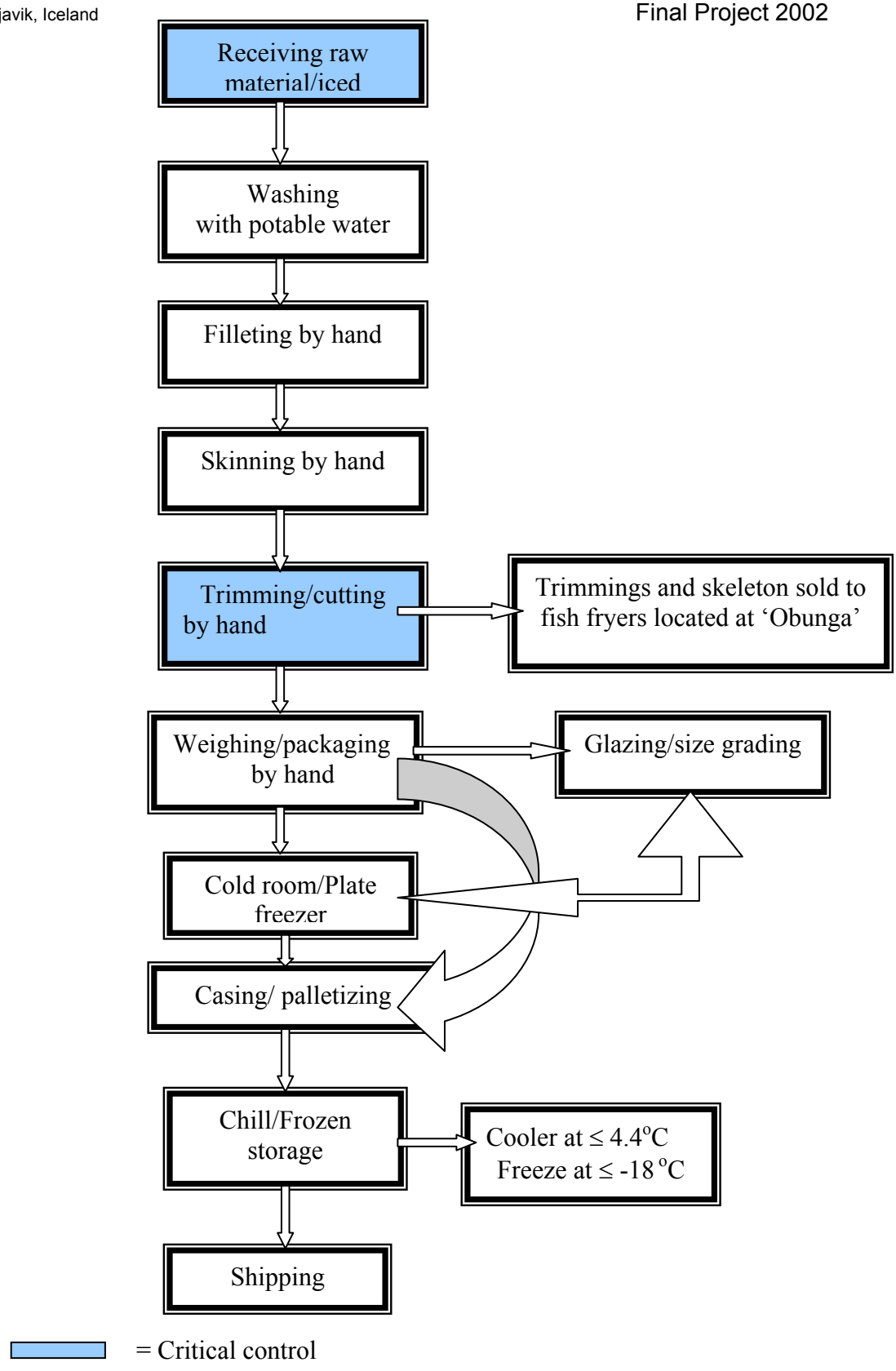

Figure 5: Flow chart for processing *Lates niloticus* and *Oreochromis niloticus* fillets in Kenya

4.4 PREMISES AND SURROUNDINGS

4.4.1 Plant Design environment

The environment in which the processing facility is situated is a critical control point in terms of the seafood product produced, i.e., if the processing plant is located in a farm area or adjacent to milling plants, there is likelihood that the dust in the air will be contaminated with animal faecal material. In case of hovering birds, bird faecal material that gets into the air must be controlled. There is need to describe location of the plant because it could be subjected to storms, floods and other natural disasters and thus quality assurance plan must have emergency procedures in place in case these disasters occur.

4.4.2 Plant Design and Layout

Figure 6 shows a generalised processing plant design. The design of premises and equipment takes into account two aspects; the construction layout and material, which both relate to prevention of contamination, ease of cleaning and disinfection. The entrance use shows how all operatives enter and leave the premises by a specific entrance, then proceeds to dedicated areas and leaves through the exit, hence there is provision for cleaning and disinfection efficiency and effective pest prevention is by the perimeter zones as in the diagram (Sharpton and Sharpton 1991, Hayes 1985, ICMSF 1986 and EEC 1991). The seafood processors need to optimise the layout and construction of the processing plant. The facility should have floors, walls, and ceilings constructed of suitable, approved materials, which are durable, smooth, impervious and easily cleaned. Walls should be light coloured and well-joined, and floors should be adequately sloped for drainage to trapped outlets. Openings to outside and/or non-food-processing or handling rooms or facilities must be sealed, while instrument panels should be appropriately locked and sealed to prevent harbourage of insects (doors made of wood to be well glued). Windows and doors must be tight and close-fitting, and doors in seafood processing areas must be self-closing.

4.4.3 Traffic Control/Controlled Access

Personnel and visitor access to specific seafood product handling areas must be restricted. Personnel involved in raw product handling (e.g., fish truck drivers, mechanics, electricians, plumbers, etc.) must not be allowed in seafood processing or finished seafood product areas. Foot baths and hand dips, where required, must be properly used and maintained. Colour coding of clothing, maintenance and other equipment should be used to clearly identify raw products verses processed product operations (Troller 1983).

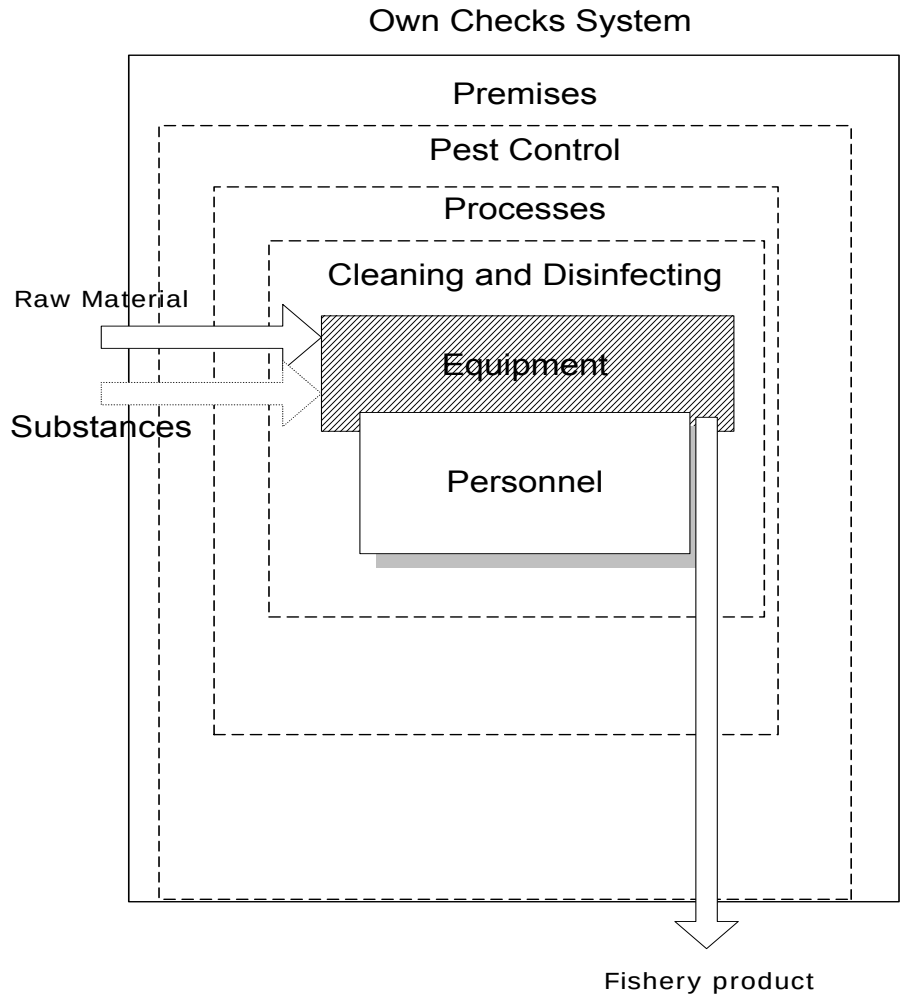

Figure 6: Generalised plan indicating flow of goods from receiving to dispatch in a seafood processing plant.

4.4.4 Outside Surroundings

Outside surroundings should be evaluated for sources of contamination such as vermin, bird harbourage areas, drainage problems, odour problems, debris, refuse, pollution, dust and other contaminants. Appropriate steps must be taken to contain and control any potential sources of contamination, i.e., by clearing the flowers adjacent to the perimeter of the wall. The two most important overall elements of seafood-processing and handling facility is that it should be cleanable, be designed and constructed in a way that it will prevent entrance or harbourage of pests or other sources of contamination (Sharpton and Sharpton 1991, Troller 1983). Unfortunately, many existing processing facilities in Kenya do not readily meet these essential elements.

Overhead structures should be situated and constructed to prevent contamination of the seafood products, and lighting to be adequate with properly sealed, safety type overhead fixtures mounted with insectocuters. Systems shall be designed and installed to prevent build-up of heat, condensation, or dust, and to remove contaminated air. Positive air ejectors are required in microbiologically sensitive areas. These systems

should be designed to be cleanable, and air intake ejectors be located to prevent intake of contaminated air. Appropriate traps and vents should be used throughout and there should be no potential of cross connections existing between human waste effluent and other wastes in the processing plant in relation to plumbing works (EEC 1991).

4.5 SANITATION AND OPERATING PROCEDURES

4.5.1 Cleaning and Sanitation for Seafood Processing

A three-word definition of food sanitation is "protection from contamination". With this in mind, all functions and operations shall be included in a sanitation programme. All seafood products shall be protected from contamination from receiving (and before) through processing distribution. Sanitation is a dynamic and on-going function and cannot be sporadic or something that can be turned on once a day, once a week, a month, etc. Since the goal of processing is to produce a safe, wholesome, unadulterated healthy seafood product to be consumed nationally and internationally, then the following procedures shall be monitored by a permanent designated employee in-charge so as to meet sanitation standards. Cleaning the processing area is made more difficult by the variety of surfaces that need attention, (Troller 1983).

A good general strategy is to make those areas closest to the product be the cleanest, because cleaning tools become less clean in use, and one should start with fresh materials near the product and clean toward the less clean areas.

4.5.2 Water safety – Water Quality

Water is one of the most important components of a seafood processing establishment since it is used as an ingredient, for conveying or transportation of seafood products, to wash fish and, it is also a habitat for the fish, to clean and sanitize facilities, containers, equipment and also as for drinking. Potable water and ice supply is imperative for sanitary seafood processing and handling, and should comply with appropriate regulations and standards and to be verified through testing programs. Water treatments (such as chlorinating systems, filtration, etc.), must be maintained, and adequate water temperatures and pressures are to be provided in processing areas to avoid baking of the soils and in general, higher temperatures results in increased inactivation rates (Sobsey 1989).

The common sources of water used in seafood processing plants in Kenya are municipal, lake water and privately dug wells. The water is thus to be supplied from a safe source because it is used in contact with seafood and seafood surfaces, safe water should be provided for ice production and there should be no cross-contamination between potable and non-potable water. Privately owned water wells shall be monitored more frequently or twice daily for suspected sources as in accordance to the requirements and the intended use before any new service is used in processing operations. Monitoring for water from the lake safety in seafood processing plant should be conducted more frequently and the same should apply to municipal water sources.

This should be in accordance with WHO requirements (1984), in state and locally approved testing water laboratories. Most water source obtained from Kisumu

municipality is expected to have high chemical and microbiological standards, unfortunately it is not fully treated, purified, or tested thus the processing plant has to test it to meet the required standard. Most chemical and microbial contamination of well water occurs due to flooding or heavy down-pour of rain, location of the well (being too close to septic tanks, cesspools, agricultural sites or associated drainage fields) and cracked or improperly sealed well casings or liners. The water used in processing at the processing plant should be treated first by chlorine injection and before production each day, the chlorine injection system to be checked for correct operation. Production should not begin until the system is operating correctly, and the injector should be monitored at each break. Non-compliance and corrective action shall be noted on the Sanitation Monitoring Report. During production, testing for chlorine content should be performed hourly at the furthest point from the injector. Failure to detect a residue at this point shall be noted in the log and corrective action, specific to each operation, will be taken and recorded on the chlorine log.

4.5.3 Seafood contact surfaces and non-contact surfaces

Before production each day, all seafood contact and non seafood contact surfaces shall be checked for cleanliness. Production shall not begin until cleanliness is confirmed to be satisfactory. All seafood contact surfaces should be rinsed down at each break to remove particulate material and at the end of production a thorough cleaning and sanitising of all seafood contact and non contact surfaces should take place. Procedures should list each piece of machinery and include a step by step clean-up procedure with chemicals used. Any non-compliance and corrective action should be noted in the Sanitation Monitoring Report. Microbial testing is necessary for monitoring the proper performance of procedures and functions of equipment; e.g., microbial load of washing tubs, conveyor belts shall be known before establishing a proper clean-up schedule.

4.5.4 Cross-Contamination

In plant water, contamination causes are usually due to cross-connections, backflow, back pressure and back siphonage. Back pressure is a source of contamination when a potable water system is connected to a system that is operating under a high pressure by means of a pump, elevation difference or air steam pressure. Raw products and employees handling raw products should be kept away from the area where finished seafood products are being handled, while backflow preventers should be installed on water lines used for processing and drinking while the methods of separation of raw product from finished product, and the procedures for preventing cross-contamination such as employee practices and movement of materials, should be listed. Storage tanks may not share common wall with tanks containing non-potable water or any other liquids, internal or interior coatings to be approved as for potable water contact (non-corrosive), while tank vents and overflow to be protected from contamination, the device for checking water level depth should not be a contaminant (Sobsey 1989). All pipes should be coloured and labelled for potable water and there should be no potable water pipes passing below or through the sewage or any other holdings of non-potable liquids. The non-potable pipes should not pass through or under tanks that are holding potable water. The corrective action for non-compliance should be listed. Non-compliance and corrective action shall be noted in the Sanitation monitoring report.

4.5.5 Sanitizing

The following items should be considered when selecting a sanitizer for a process operation.

- The length of time the sanitizer will be in contact with the surface to be sanitized. If the equipment is soaked, then the rate of sanitizing action is relatively unimportant.
- The temperature at which the sanitizer will be used. E.g. in the case of chlorine, as the temperature is increased, chlorine is less effective.
- The amount of organic material (fats, proteins, vegetable materials, etc.) present in or on the equipment to be sanitized. If the equipment to be sanitized contains many particles of organic matter in addition to bacteria, the sanitizer will concentrate on the organic particles and combine with them rather than the much smaller bacteria. On the other hand, if the equipment is relatively clean and if bacteria comprise the majority of the particulate matter on the equipment, then the sanitizer will be more effective.
- The cost of the sanitizer. No matter how efficient a sanitizer may be, its cost may limit its application. Before selecting a sanitizer, review all considerations in order to determine the most economical one to use for a particular job.
- It is important to know the pH of the solution in which the sanitizer will be expected to act on. Again, using chlorine as an example, the lower the pH the more effective chlorine is as a sanitizing agent. pH 7 is ideal, and never mix chlorine with an acid, it is almost always fatal.

Dip utensils, equipment parts, etc., in a chemical solution or in 82°C water for 30 seconds to complete the sanitizing process. Sanitize stationary equipment by use of a pump sprayer so as to enable the sanitizer to penetrate the entire machine. A small hand held spray type bottle should be used in restrooms, for table sanitizing. In Kenya and other parts of the world the most generally used sanitizer is chlorine, the ability of any sanitizer to inactivate or kill micro-organisms is dependent upon the germicidal action of the sanitizer itself (i.e. its selectivity and concentration, the length of time during which the sanitizer is in contact with the surface being sanitized, the number and characteristics of the micro-flora present, the temperature, the pH and the amount of organic matter and other incompatible materials, such as mineral deposits). The greater the number of micro-organisms present, the more difficult it is to effectively remove them. Certain sanitizers are more effective or have a greater germicidal action than others. For instance, chlorine can be purchased in the form of sodium hypochlorite in 5%, 11%, and 15% solutions. Naturally, less quantity of the 15% solution is needed than that of the 5% solution. If mineral deposits, milkstone or other incompatible materials are present on the surface, sanitizers cannot penetrate to the bacteria and therefore, the cost of the sanitizer is wasted.

Note: dirt cannot be sanitized and when choosing a sanitizer, take care to determine the surface makeup of the equipment that is to be sanitized, e.g., if chlorine is used in high concentrations on stainless steel equipment, pitting of the equipment will eventually occur since chlorine in solution forms an acid and likewise, the use of iodophores on belts and other pieces of equipment that can absorb sanitizers tend to stain the equipment.

Do not use phenols in seafood processing plants, because it is difficult to determine whether or not the processing plant has been cleaned or the phenol compound has simply been spilled in an area within the process plant. The odours of a phenol can penetrate food materials, causing undesirable flavours and odours in the seafood products. Quaternary ammonium compounds (QUATS) have been used in seafood processing plants. However, their use has been limited in Kenya due to the cost of these compounds. Chemicals used will be listed as the non-seafood compounds. Material Safety Data Sheets have to be available for each chemical used.

4.5.6 Factors Affecting Sanitizer Effectiveness

Physical Factors

Surface Characteristics - Prior to the sanitization process, all surfaces must be clean and thoroughly rinsed to remove any detergent residue. An unclean surface cannot be sanitized. Since the effectiveness of sanitization requires direct contact with the micro-organisms, the surface should be free of cracks, pits, or crevices which can harbour micro-organisms. Surfaces which contain biofilms cannot be effectively sanitized.
Exposure Time - The longer a sanitizer chemical is in contact with the equipment surface, the more effective the sanitization; intimate contact is as important as prolonged contact, but is not so for chlorine which evaporates with time.
Temperature - Temperature is also positively related to microbial kill by a chemical sanitizer. Avoid high temperatures (≥55°C) because of the corrosive nature of most chemical sanitizers.
Concentration - The activity of a sanitizer increases with increased concentration. However, a levelling off occurs at high concentrations. A common misconception regarding chemicals is that "if a little is good, more is better". Using sanitizer concentrations above recommendations does not sanitize better and can be corrosive to equipment and in the long run lead to less cleanability (follow manufacturer's label instructions).
Soil - Presence of organic matter drastically reduces the activity of sanitizers and may totally inactivate them. The adage is "you cannot sanitize an unclean surface".

Chemical Factors

pH - Sanitizers are drastically affected by the pH of the solution. Chlorine sanitizers are almost ineffective at pH values >7.5 (Sobsey 1989).

Water properties - Certain sanitizers are markedly affected by impurities in the water. The water should be free of minerals, free of micro-organisms, clear, colourless and non-corrosive. Hard water contains minerals that may react with some cleaning compounds and thus prevents them from working properly.

Inactivators - Organic and/or inorganic in-activators may react chemically with sanitizers giving rise to non-germicidal products. Some of these in-activators are present in detergent residue. Thus, it is important that surfaces be rinsed prior to sanitization.

Biological Factors

The microbiological load and the type of micro-organism present can affect sanitizer activity. Spores are more resistant than vegetative cells. Certain sanitizers are more active against gram positive than gram negative micro-organisms, and vice versa. Sanitizers also vary in their effectiveness against yeasts, moulds, fungi, and viruses.

4.5.7 Monitoring and Testing

They need to monitor temperature and the operation of the processing machinery, refrigeration systems, conveyor belts and chlorination systems is very vital. Start with five fundamental questions who, what, when, where, why and how, are the instructive with regard to sampling the plant. The primary question is why the sampling is being done, which will help determine the answers to the other questions.

*Why – The three main reasons to sample areas to be cleaned or that have been cleaned is to:-

determine the initial contamination level and the degree of need for cleaning
determine the final contamination level remaining after cleaning
determine the removal efficiency of a cleaning technique, i.e., [1-(final level)/(initial level)]

* Who – Sampling should be done by production personnel under the supervision of the quality group. Adding non-production personnel to the area being sampled risks needless contamination and other disruptions to the processing routine.

* What – Contamination levels to be measured include particles, microbes, product residues and cleaning agent residues. Samples are taken from surfaces, gases and liquids to reflect the levels of biological, chemical and particulate contamination.

* When – Although cleaning can be scheduled strictly on the basis of time since the last cleaning or before the start of certain production changes, monitoring contamination levels before cleaning and over time is informative with regard to the adequacy of the scheduling. The more frequent the sampling, the more informative the test results.

* Where – Sampling shall be most informative in areas where the value of cleaning is greatest, namely near the product, in areas that are hard to clean and in representative areas, which are small areas that are similar to larger areas of interest or are taken from a few instances out of a multitude of instances. Areas that are difficult to clean should be minimised in the design of the facility and choice of equipment. This shall encompass avoiding surfaces that are not smooth and flat, corners, depressions and knurled or roughened surfaces, areas that are a challenge to reach, porous regions, and heated regions which are not easy to clean because they will accumulate material that has been in liquid that has subsequently evaporated, and because the usual increase of adhesion over time will be accelerated by heat. Fortunately/unfortunately, areas that are hard to clean are often hard to sample.

*How – Samples should be taken from a defined or selected area. Typically, partially overlapping parallel strokes shall be used. Where there are different surface textures

in one direction versus another, a second sampling with partially overlapping strokes should be taken at right angles to the first.

4.6 OPERATIONS

4.6.1 Temperature Control

The rule of sanitation should be to pay strict attention to seafood temperatures, by avoiding prolonged holding in the danger zone (from 4°C to 60°C) and provide functional thermometers to all seafood storage boxes. Monitor the temperature on serving lines on a regular frequency. Thaw frozen seafood under refrigeration or under cold water. Do not thaw seafood at room temperature.

4.6.2 Hygiene

Regardless of type of processing or seafood handling operation, the number one consideration in seafood sanitation is people. It is people who set the rules, follow the rules, and also break the rules of sanitation. A sanitation program is as good as the attitude, willingness, and efforts of people. That is why the most important aspect of a sanitation program is ongoing personnel training. It is essential that everyone concerned in the seafood system-including management accept the full meaning of sanitation and its wide economic scope. Personnel training shall include appropriate sanitation principles and seafood handling practices, manufacturing controls, and personal hygiene practices. A well co-ordinated and holistic approach towards hygiene is an essential element of seafood quality and safety

4.6.3 Employee Health

Employees with communicable diseases/injuries, such as respiratory, gastrointestinal, typhoid and infectious hepatitis will be restricted. The chain of command for reporting illness shall be listed. Persons known to be suffering from, or known to be carriers of a disease likely to be transmitted through seafood, must be restricted from any seafood-handling area. Likewise, persons afflicted with infected wounds, skin infections, sores, etc., must also be restricted from these areas. Any persons with open cuts or wounds shall not handle seafood unless the injury is completely protected by a secure, waterproof covering.

4.6.4 Employee Practices

Hand washing facilities with hot water, soap, and single service towels shall be available in restrooms and before seafood production each day, the restrooms, break areas shall be checked for cleanliness and adequate supplies of soap, towels, and toilet paper. Hand dip stations shall be put ready for process with specified concentrations of chlorine or iodine sanitizers. Hand dip solutions should be changed as frequently as necessary to maintain effectiveness and processing shall not begin until conditions are satisfactory. Personal Cleanliness and Conduct shall be maintained while involved in seafood handling operations: Sanitary protective clothing, hair covering, and footwear must be worn and maintained in a clean, sanitary manner. Gloves, if worn, must be clean and sanitary. All seafood-handling personnel must remove objects (i.e., watches,

jewellery) from their hands as this may fall into or contaminate the seafood product. Tobacco, gum, and food are not permitted in seafood-handling areas (Thorpe, 1992).

4.6.5 Protection from Adulteration

Throughout processing up to shipment, product shall be monitored periodically for adulteration, i.e., the area, frequency of monitoring and the corrective action for non-compliance shall be specified. Before production each day each item of machinery shall be checked to see that it is in good repair, and properly cleaned and sanitised. Production shall not begin until equipment is properly cleaned, sanitised, and in good shape, while during each break and after each breakdown of equipment, machinery is to be checked to ensure all damaged and broken parts are accounted for and records kept by the store man/supplies officer.

4.6.6 Protection from Contamination

The seafood facilities, various non-seafood product contact surfaces and equipment shall be evaluated to assess potential for seafood product contamination. Shielding from overhead contamination shall be provided as deemed necessary. Examples include: shielding over seafood product filleting tables or trolleys, shielding from refrigeration unit drip in coolers, sneeze guards on seafood process lines, etc. Cold storage and engineering rooms must be separated from seafood processing and handling areas, minimise traffic to prevent contamination and it is desirable to have a seafood product flow-through that physically and operationally separates raw product functions from processing functions and finished product functions in order to avoid cross-contamination.

4.6.7 Storage of cleaning chemicals

Before any processing/or production the warehouse/storage area has to be checked for cleanliness each day. Container storage, and chemical storage areas will be labelled such as Alkaline: red colour, square symbol, Caustic: purple colour, rhombus symbol, Acidic: brown colour, triangle symbol, Disinfectant: blue colour, rectangle symbol, Chlorinated: yellow colour, pentangle symbol and Neutral: green colour, circle symbol as in compliance with requirements. Avoid storage of chlorine and acid in the same compartment.

4.6.8 Pests

To assure seafood has been processed, packed and held under sanitary conditions, The Federal Food, Drug and Cosmetic Act of the Food and Drug Administration (FDA) states the following: "Sec. 402. A food shall be deemed to be adulterated, (3) if it consists in whole or in part of any filthy, putrid, or decomposed substance, or if it is otherwise unfit for food; or (4) if it has been prepared, packed, or held under unsanitary conditions whereby it may have become contaminated with filth, or whereby it may have been rendered injurious to health;" Thus exclusion of Pests before production commences each day, provisions for exclusion of pests must be checked. Insectocuters must be cleaned daily, and the corrective action for non-compliance should be listed. This will be done by the prevention pest control

technician. Control of pests and use of pesticides are particularly critical in places where seafood is processed, or packaged.

Most seafood industries are inspected for sanitation by ministry of health on behalf of Kenya government. Regulatory action can be taken if seafood becomes contaminated, or is processed, packed or held under conditions where it could become contaminated with insect fragments, rodent hair, bird feathers, faeces, etc. Top management is ultimately responsible for identifying a competent person to develop a pest prevention and control program. These people should be given the necessary support to carry out the program and ensure that pesticides are used in accordance with label instructions. Persons applying pesticides in industrial and institutional settings have a responsibility to use the needed pesticide, to apply it correctly (according to label instructions), and to be certain there is no hazard to man or the environment. The guard against the spread of micro-organisms and filth by flying and crawling insects, rats, mice, and other vermin should be a priority.

Pest control is often ignored until pests and their damages are discovered in the tropics, i.e., if rodents or insects are found in a seafood storage room, temporary measures are taken to eliminate them and the real trouble, is not corrected. This is a situation where joint effort is needed most, including inspecting incoming seafood trucks or handcarts for evidence of insects (cockroaches in particular) or rodents before unloading/loading it. Rodent-proof the room, store seafood off the floor, keep the room clean, and inspect the room for insect and rodent activity on a regular basis. The method of treating a single outbreak is a poor concept of sanitation, reason being that in the heavily regulated seafood industry, this could be disastrous since contaminated seafood are always seized and destroyed and the fines levied against the processor. It also leads to embarrassment, bad publicity and economic loss to a seafood processing plant /government and becomes worse than regulatory actions (as the case of bans placed by EU, of 27th Nov, 1996; 23rd Dec, 1997 and 26th March, 1999). The processor has to take every fitting precaution to exclude the pests from all sections of the seafood processing plants.

4.6.9 Pollution caused by waste disposal

Solid waste disposal is a major drawback in seafood processing plants in western part of Kenya, and there is need for the processors to have landfills for their wastes. Seafood waste materials are hard to contain, reason being that of large amounts of carbohydrates, proteins, fats and minerals. *Listeria monocytogenes* has been isolated from seafood processing effluent and sewage and thus it is a concern to aquatic environment. The discard smells terrible, and thus there is need for treatment and biological stabilisation of organic matter before discharge to the rivers, streams and into the lake, since improper waste disposal is hazardous to humans and aquatic life. The prompt and complete disposal will help curb the insects, rodent attraction and cockroach breeding areas. Waste facilities designed to prevent contamination must be provided for the sanitary storage of waste and inedible material prior to their removal from plant or surroundings. Waste containers are to be clearly identified especially the ones of skeleton for further sale.

4.6.10 Sanitary Facilities

Self-closing doors must be provided for all washrooms. Washrooms, restrooms and change rooms must be separate from and not directly entered from seafood processing and handling areas. Such facilities are to be properly ventilated and maintained at all times. Sufficient numbers of hand washing sinks, with hot and cold potable water, soap, sanitary hand drying towels, which are not reusable, must be provided in washrooms. Sufficiently suitable hand washing sinks must be located in seafood processing and handling areas. Hand-washing sinks should be separate from sinks used for equipment cleaning and other operations and should be checked for clogging and cleaned regularly.

4.6.11 Recordkeeping

This is to allow for more effective and efficient company oversight and also allows the inspectors to follow how the processors are complying with seafood safety standards over a duration of time rather than how well it is doing on a specific day. Report Forms - Information collected and corrective action taken shall be recorded on appropriate report forms.

5. INSPECTIONS

5.1 Internal Inspection

An important part of a quality system is a good inspection system and the most legitimate questions to ask are: Is it feasible?, Is it desirable?, Is it necessary? and Is it certain?. The answer is yes, because you are to improve quality and safety of seafood products and accomplishing thorough process control. Table 5 shall be used as guidance during inspection monitoring.

Table **5**: The eight conditions for sanitation (FDA Seafood HACCP Regulation, 21CFR, Part 123.11)

1. Safety of the water that comes in contact with seafood or surfaces or for use in manufacture of ice
2. Maintain cleanliness of seafood contact surfaces, inclusive of gloves, facilities and outer garments
3. Maintain hand washing, sanitizing and toilet facilities
4. Prevent cross – contamination from unsanitary objects to seafood (packaging, gloves, raw to processed, clothes, etc).
5. Control employee health conditions that could result in contamination of seafood
6. Make proper use of toxic compounds by labelling and separate storage
7. Prevent seafood packaging material and contact surfaces from adulteration with lubricants, fuel, pesticides, cleaning compounds, sanitizing agents, condensate and other chemical, physical and biological contaminants
8. Exclude pests from seafood plants in and around the plant

5.2 Official Inspection

Seafood control systems are reliant on fisheries department inspectors and public health officers to provide the manpower. Generally these officers are appointed at a number of levels of the Kenyan government. The national food control and inspection staff is usually appointed under ministries of health, and additional inspectors are

under ministries such as agriculture, industry and commerce to inspect raw materials and products to determine compliance with standards, but in real sense these divisions are grossly under resourced in both equipment and personnel. Other levels that employ inspectors are provincial, municipal and district authorities, and this has led to duplication of responsibilities and a lack of accountability which in an atmosphere of gross understaffing (World bank retrenchment scheme) results in no one taking responsibility, because there is insufficient number of inspectors to undertake inspection duties, and as a result, unscrupulous fish processors has a high likelihood of going without detection. The seafood product storage areas should be checked daily to ensure that equipment such as shovels, buckets, brooms that come in contact with the floors or waste are kept separately. Equipment shall be cleaned with hot water if need be and then sanitized. This is to aid in softening the biofilms of some micro-organisms such as, *Salmonella*, *Listeria*, and *Pseudomonas* that uses filaments or tendrils to attach themselves to seafood contact surfaces.

5.3 Equipment Calibration

Protocols and calibration methods must be established for all equipment that could impact on seafood safety. Such as: thermometers, pH meters, water activity meters, refrigeration controls, scales, recording thermometers, etc.

All reagents used for monitoring and verification must be documented and stored properly. Appropriate monitors must be used. The preventive checklist will be used by the processors for the inspection purpose, i.e., the variety of items to be inspected on routine basis.

5.4 Hygiene Audit

The floors shall be examined so as to ensure that there is no physical damage which might be a harbour for insects and rodents, or which might lead to the accumulation of the filth from transport carriers which might attract pests and enable the growth of potential microbial contaminants (ICMSF 1986). There must be at least a daily review of CCP records to ascertain, insofar as possible, that the monitoring has been performed and recorded correctly, and that appropriate corrective actions have been taken. The walls shall be examined to ensure that they are in sound condition with no damage which might cause problems again with insects and rodents. All the crevices and cracks to be filled with cement as soon as possible.

6. HACCP CO-ORDINATOR AND HACCP TEAM

During processing there is always substantial increase in bacterial numbers on the fish. Thus when setting up a HACCP team, it is important to know which bacteria might be present, and at which points they are liable to contaminate the fish and seafood and how the contamination can be controlled. The guiding principle throughout will be that seafood processors bear full responsibility for the safety of the seafood they produce. Implementation of hazard analysis and control principles and observance of hygiene rules shall be applied to all levels of seafood chain and must ensure safety. However, a comprehensive regulation shall be proposed to the HACCP

team recasting the handling of fish at the beaches so as to introduce principles and observance of hygiene rules, to be applied at situations like in Figures 7 and 8.

Figure 7: Landing beaches in Kenya where handling of the fish is very important and of great concern because of unavailability of ice facilities.

The HACCP team shall examine how best it deems fit to assist small and medium scale harvesters in implementing the HACCP requirements, mostly by development of guidance documents in addition to laying down seafood safety objectives and training. But where need be ATP bioluminescence criteria shall be introduced to agents, brokers, auction-leaders and transporters as a matter of priority. The contents in Table 6 and 7 shall be used as a predictive seafood model for useful information and assist in decision making while looking at HACCP principles described by NACMCF (1992). There is need for the HACCP team to address the need for headgear which completely encloses the recruited persons handling fish at the beaches as shown in Figure 8.

Figure 8: Fish processor's agent taking samples from a catch. In this situation the use of ice is of great concern.

Table 6: Differenting HACCP and Sanitation Control Programme

Hazard	Control	Type of control	Control programme
Chemical contamination	make sure seafood grade is used	Plant environment	Sanitation
Pathogen contamination	Clean and sanitize seafood contact surfaces	Plant environment	Sanitation
Pathogen contamination	Limit employee movement between raw material and finished processed product	Personnel	Sanitation
Pathogen contamination	Washing hands before touching seafood product	Personnel	Sanitation
Pathogen survival	Time/Temperature of icing and freezing	Processing step	CCP
Histamine	Temperature and time of fish type	Product specific	CCP

HACCP Co-ordinator:- The HACCP Co-ordinator is the person with primary responsibility for Seafood Processing Company. HACCP programme. The HACCP Co-ordinator is also to be in charge of the HACCP Team.

HACCP Co-ordinator:-

Name Position Training Received

HACCP Team:- HACCP team is to consists of the HACCP Coordinator and three additional HACCP team members. HACCP team will consist of the right blend of experts. The team will collect, collate and evaluate technical data, identify hazards and CCP and should be composed of quality assurance/control staff, production personnel, an engineer and a microbiologist. A consultant, to be approached to help the HACCP team develop the HACCP plan.

HACCP Team Members:-

Name Position Training Received

Name Position Training Received

Name Position Training Received

Consultant:-

Name Position Training Received

Table 7: Summary of the hazard analysis to be followed in the fish processing plant

Process Step	Potential Hazard (added, enhanced or controlled)	Rationale for Inclusion or Exclusion as Significant Hazard	Significant Hazard? Yes / No	Preventive Measures or Controls	Critical Control Point? Yes / No
Fish Reception	Chemical (heavy metals, natural toxins, industrial, agricultural chemicals)	Not reasonably likely to occur.	No	trucks inspection and incoming fish.	No
	Physical (foreign objects e.g., fish hooks, wood wire of fish gear)	Not reasonably likely to occur.	Yes	Inspection of trucks and incoming fish.	No
	Biological (pathogens) (decomposition)	Microbial toxins are not reasonably likely to occur during decomposition	No	Inspection of incoming fish.	No
Storage of raw product.	Biological (decomposition)	Microbial toxins are not reasonably likely to occur during decomposition	No	Proper storage temperature/use of ice.	No
Water and ice	Biological (pathogens)	Pathogens may be found in water and ice.	Yes	Acceptable water source.	No
Butchering Operations and Cutting	Physical (foreign objects)	Not reasonably likely to occur.	No	Employee practices and preventive maintenance.	No
Empty tubs	Biological (recontamination of product with pathogens)	Defective tubs can allow entry of pathogens.	Yes	Inspection of empty tubs	Yes
Air cooling	Biological (recontamination of product with pathogens)	Recontamination not reasonably likely to occur.	No	Adherence to SSOP's and GMP's that apply to product cooling	No

7. CONCLUSION AND DISCUSSION

Currently all over the world, there is increasing consumer concern and public perception regarding seafood safety and this requires more government/state inspection effort, for as far as I know a parsimonious/parlance approach ultimately leads to disaster. There is need to take part in some aspects of processing plant inspection facilities, shoreline sanitary surveys, patrolling of harvest areas and creating voluntary inspection of fish and fishery products. The Kenya government should enact a sanitary act to create programmes for the processors. The act should focus towards developing a voluntary Kenya grade standard for fishery products and in-plant process and seafood product inspections. This will be one way of promoting

products as safe, wholesome and of high quality. It should be a free service in that processors and stakeholders must not pay for the state inspections concerning cleaning-sanitation and HACCP development programme. This programme should be continuous and be extended to handling at harvesting vessels, transport trucks, ice availability, lot inspection, grading, processing plants and establishment. However, the programme after some time should be modified to encourage the stake holders to develop and implement their own HACCP-Sanitation system and quality control assurance system. There should also be responsibility to establish a pesticide residue tolerance in seafood, restoring the water quality to provide for safe seafood and for the protection and propagation of fish. The primary focus on this is to reduce pollutants in fish growing waters and there should be research conducted by employing chemical and biochemical analysis in classifying the indicators for justification of HACCP concept development.

Finally, I would like to emphasise that the principles of HACCP should be incorporated into national fishery regulations, but it should be noted that HACCP deals with uniqueness, while regulatory or surveillance inspections deals with general issues, which can be re-addressed in regulations to cover the whole fishery industry as per quality issues. Bacterial control of cleaned and sanitised equipment by means of ATP bioluminescence or agar impressions (RODAC) is carried out weekly. Water quality monitoring should be done by control of chlorine level daily and, microbiological testing once or twice a week and as soon as the system is acquainted and works well, it can be reduced to an occasional checks for betterment of seafood process and quality product.

Considering the type of fishing methods, time to land fish and vessels used, sensory and temperature assessment of raw material immediately before processing is necessary for ensuring that until this point, the material has been under control and that spoiled fish does not enter the processing area. An important part of HACCP concept is monitoring and verification. It is not difficult to wash a dirty wash tub, after it has been used for holding high bacterial count fish, using established procedure and to measure with a simple ATP or RODAC microbiological contacts to determine if bacteria are at a safe level.

7.1 Limitation

There is still much to do as per this project guide as concerns HACCP concept. Contamination with bacteria from human/animal reservoir shall be monitored. On this, monitoring of the aquatic environment, fishing areas, fishermen practice and control of fishing if pollution is evident shall be done in Kenya so as to come up with a complete seafood processing Sanitation-HACCP guide. The major change is for the processors to accept more responsibility for their own performance, i.e., they should not rely on inspection bodies to identify for them non-compliance, determine the appropriate corrective action, provide solutions and then sit on the high table to negotiate dates and time for corrections. The government inspectors shall continue to conduct inspections of seafood product, process and facilities as at present, but shall inspect processor's inspection activities at all critical points cited.

7.2 Recommendation

There is need for use of rapid methods for determination of spoilage sources and factors of fish and seafood quality for use in HACCP based control systems. In view of the demanding import market standards and food regulations, there is an urgent need to train personnel to investigate all quality parameters (biochemical, chemical, microbiological, physical) so as to develop an effective system for quality maintenance in relation to processing in fisheries sector. The training of personnel shall be of great importance on HACCP related issues that shall be applicable in controlling of fish processing at both artisanal and industrial level. If this is done, shall help dictate experimental clarification criteria to be used in applicable Sanitation-HACCP system for assuring safety of seafood. This shall be a means of preventing problems before they occur while looking at quality as a joint government-industry system in conjunction with increased communication and understanding with the scientific community. This is the only way for HACCP system to be operational and applicable, but not as a static-rubber stamping tool and for HACCP system to be effective, it should be applied from the origin of the seafood and its acceptance requires mutual trust. Non existence of this trust between the regulator and the regulated, the systems seems to head nowhere.

Acknowledgement

Too often, those who do the work' are not acknowledged in the development of programmes and resources that we come to depend upon for our courses like this one. I extend my heartfelt thanks to UNU/FTP and everyone involved in the development of this programme. Thank you to all those unsung contributors (laboratory staff, computer, library, electricians and fish processing companies).

Success of this project fully depended on funds from UNU/FTP, while the conducive environment of Icelandic Fisheries Laboratory and Library was vital for my reviewing scientific literature, Kenya Government regulations (which were scattered in various ministries), monographs, bibliography, FDA and EU regulations, Icelandic laboratory research findings, quality regulators manual and fish processing plants HACCP systems, dissertations and scientific pamphlets. Working in tandem with my supervisors made me complete this project, and I appreciate them for that. Successful people only succeed because they learn from their failures and it takes deep commitment to change and an even deeper commitment to grow. ***Thank you.***

Dedication

To my father who warned me to be aware of the bad in the best of us.
To my late mother who told me to look for the good in the worst of us.
I am also indebted to my children, Mercy, Nancy, Vivian and the newly born baby boy (*Herman-Hume*) for their co-operation to their mother for the six months of my stay in Iceland.
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REFERENCES

Ababouch, L. 1991. Histamine food poisoning. An update. Fish Tech News. 11: 3-5, 9.

Abila,R.O. and Eirik G. J., 2001. From local to global Markets: The processing and exporting industry on the Kenyan part of Lake Victoria – its structure, strategies and socio-economic impacts. Working paper 1997.8.

Barile, L.E., Milla, A.D., Reilly, A. and Villadsen, A., 1985a. Spoilage patterns of mackerel (*Rastreliger faudhni* Matsui). 1. delays in icing. ASEAN Food J., 1(2), 70.

Chesworth, N. 1997. *Food Hygiene Auditing*. Blackie Academic & Professional. London 1st Ed.

Dunsmore, D.C. and Thompson, M.A., 1981. Bacteriological control of food equipment surfaces by cleaning systems. II. Sanitizer effects. J. Food Protect. 44, 21-27.

Dunsmore, D.C. Westwood, D.A., Jay, D.B. and Embling, M. 1980. Simulator technique for assessing the bacteriological control of food equipment surfaces by cleaning systems. J. Food Protect. 43, 850-855.

EEC 1991. Council Directive N°. 91/493/EEC: Laying down the health conditions for the production and placing on the market of the fishery products. Official journal of the European Communities N°. L 268/15

Einarsson, H. and Guðbjörnsdóttir, B., 1997. Hygiene in Icelandic fish processing plants. Icelandic Fisheries Laboratory Report N°. 10-98.

Food and Agricultural Organization (FAO) 1973. Code of practice for fresh fish. FAO Fisheries Circular C318, FAO, Rome Italy.

Food and Agricultural Organization (FAO) 1994. FAO fisheries technical paper N°. 334

Food and Agricultural Organization (FAO) 1998. FAO statutory instrument N°.994 FDA regulation 21CFR113

Food and Agricultural Organization (FAO) 2003. Fisheries Databases and Statistics. www.fao.org/fi/statist/statist.asp

Garret, E.S. and Huddak-Ross, M.,. 1991. US Seafood Inspection and HACCP, in Microbiology of Marine Food Products, (eds D.R. Ward and G.R. Hackney), Van Nostrand Reinhold, New York, p. 111

Gram, L. Oundo, J.O. and Bon, J., 1989. Storage of Nile Perch (Lates niloticus) in relation to temperature and initial bacterial load. Trop.Sci., 29, 221.

Hayes, P.R., 1985. Food Microbiology and Hygiene. Elsevier Applied Science

Hospitality Institute of Technology and Management (HITM) 2001. Microbiological Sampling Food Contact Surfaces and Food. <http://www.hi-tm.com>

Huss, H.H., 1992. Development and use of the HACCP concept in fish processing. *Int. J. Food Microbiology* 15, 33

ICMSF (International Commission on Microbial Specifications for Foods) 1986. Microorganisms in Foods. 2. Sampling for microbiological analysis: Principles and specific applications. 2nd Ed. Blackwell Scientific Publications.

Kricka, L.J., Stanley, P.E., Thorpe, G.H. and Whithead, T.P., 1984. ATP assay as a rapid method for estimating microbial growth in foods. In: Analytical applications of bioluminescence and chemiluminescence. ISBN 0-12-4262902, Academic Press, pp. 53-56.

Langeveld, L.P.M. and van de Waals, C.B.,1988. The ATP platform test. ATP test and the direct microscopic count procedure as methods of estimating the microbial of raw milk. Neth. Milk Dairy J. 42, 173-183.

Marriot, N.G 1997. *Essentials of Food Sanitation*. Chapman & Hall. Food Science Texts. New York.

Martin, A.M., 1994 *Fisheries Processing*. Chapman and Hall. Biotechnological Applications. London 1st Ed.

Sharpe, A.N., Woodrow, M.N. and Jackson, A.K., 1971. Adenosine triphosphate levels in foods contaminated by bacteria. *J. Appl.Bacteriol.* 33, 758-767.

Sharpton, D.A. and N.F. Sharpton 1991. *Principles and Practices for the Safe Processing of Food*. Butterworth & Heinemann.

Simpson, W.J., 1989. 'Instant' assessment of brewery hygiene using ATP-bioluminescence. *Brewers' Guardian* 118, no. 11, 20-22.

Sobsey, M.D., 1989. Inactivation of health-related microorganisms in water by disinfection processes. *Wat. Sci*. 21 (3) 179-195

Thompson, P., 1989. Rapid hygiene analysis using ATP bioluminescence. *Food Anal. Control* 16, 42-48.

Vanderzant, C. and. Splittstoesser D.F., 1992 *Compedium of methods for the microbiological examination of foods* 3rd Ed.

Thorpe, R.H., 1992. Hygienic design considerations for chilled food plants. In *Chilled Foods. A Comprehensive guide*. C. Dennis and M. Stringer eds. Ellis Horwood.

Troller, J.A., 1983. *Sanitation in Food Processing*. Academic Press.

Ward, D.R., LaRocco, K.A., and Hopson, D.J., 1986. Adenosine triphosphate biolumonescent assay to enumerate bacterial number on fresh fish. *J. Food Prot*. 49.

WHO 1984b. *'Guidelines for drinking water quality'*, Vol. I, II & III. World Health Organisation, Geneva.

WTO 2001. Food safety and health implementation; 'equivalence' decision OK'd. Sanitary and Phytosanitary measures 24/10/2001 agreement article 4 equivalence.

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APPENDIX 1 – CALCULATIONS

How to obtain a specific parts per million (ppm) solution from a given solution of detergent. Take chlorine as an example. Usually sodium hypochlorite is packaged as 5.25% chlorine solution in many shops. Then expressing this as a decimal, we divide it by 100% which gives 0.0525. Hence to get ppm, we have to multiply 0.0525 by 1,000,000 which gives 52,500 ppm of chlorine.

To get a specific ppm, say 400 ppm, use the below equation:

Eq. 1.....1part ÷ 52,500 = X ÷ 400ppm

$\therefore$ X = 0.007619

This means that you are to should use 0.007619 ml chlorine per ml of water. But since measuring 0.007619 ml is difficult, then multiply by 1,000 ml (1 litre).Therefore 7.619 ml of chlorine in 1 litre water will provide a 400 ppm in solution, which is the same in ounces or gallons, i.e. 0.007619 oz. chlorine per oz water = 400 ppm. Again multiplying by 1,000, 7.619 oz. per 1000 oz. water (15.238 gallons) = 400 ppm.

Eq. 2.....0.007619 gallon Chlorine per gallon water = 400 ppm, or 0.975232 oz. Chlorine per gallon (0.007619 x 128 oz. in a gallon), thus 7.619 gallon water = 400 ppm.

Processing plant purchases industrial strength chlorine, and it contains 15% chlorine. we need to fill a gallon holding with 400 ppm of chlorine. How much of the 15% chlorine shall we use?

Solution:

15 ÷ 100 = 0.15 ÷150,000 ppm

1 part ÷150,000 = X ÷ 400 ppm

X = 400 ÷ 150,000

X = 0.0026666 oz. Chlorine ÷ oz. water.

Hence use 0.0026666 oz. chlorine / oz. water

Since there are 128 oz. per gallon, then:

[(128 oz. H_2O ÷ gallon) x (0.0026666 oz. Cl ÷ oz. H_2O)] = 0.3413248 oz.Cl ÷ gallon

$$\frac{0.3413248 \text{ oz. Cl}}{\text{gallon}} \times 5 \text{ gallon} = 1.706624 \text{ oz. Cl.}$$

Thus mix 1.706624 oz. Chlorine with 5 gallons water to obtain a solution with 400 ppm chlorine.

Temperature

Temperature conversion parameter to be used in the processing plant, Kenya.

Equation 3.....^{o}F to ^{o}C = 5/9 x (^{o} F – 32)

Equation 4.....^{o}C to ^{o} F = (9/5 x ^{o}C) + 32

Eq.5.....Amount of Ice to be used = weight of fish x sp.ht.cap.H_2O x Δtemp ÷ Lt. ht. of ice

where:

specific heat capacity of water is 3600J/Kg^{o}C

Latent heat of ice (Lt. ht.of ice) is 335Joules

Δtemp is change in temperature

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APPENDIX 2

Table A-1. A result survey of samples taken on 1st and 2nd December 2002 in a plant located in Reykjavik, Iceland

Description of environmental sampling facility site	After cleaning				In process after 8 hours	
	ATP rlu/10cm^2	RODAC cfu/plate	Swabbing cfu/cm^2	*Listeria* per 50cm^2	Swabbing cfu/cm^2	*Listeria* per 50cm^2
1. Washing tub	2481	> 100	6	negative	308,000	negative
2. Grading machine	229	67	2	negative	17,200	negative
3. Beheading machine (roller)	6990	> 100	170	negative	55,000	negative
4. Filleting machine (steel plate)	933	> 100	100	negative	4,500	negative
5. Deskinning machine Steel plate)	194	> 100	1	negative	600	negative
6. Cutting machine knife	24	< 1	< 1	negative	3,000	negative
7. Weighing machine	969	63	3300	negative	< 1	negative
8. Trimming machine	124	> 100	6	negative	420	negative
9b. New slicing machine	249	> 100	6800	negative	3,000	negative
9g. Knife in the new machine	377	> 100	2600	negative	1,320	negative
9p. Overhead plastic drain	442	> 100	100	negative	84	negative
10. Plastic table hand trimming	2076		< 1	negative		negative
11. Trimming machine steel plate	3976	87	< 1	negative		negative
12. Conveyor belt from IQF	86	> 100	3900	negative	240	negative
13. Conveyor belt from degrading machine (plastic)	91	3	< 1	negative	6	negative

Table A-2. Number of microbes in fish and seafood product from the processing plant located in Reykjavik, Iceland.

Description of product samples	**In process**			
	After 8 hours (TVC)	*Listeria* per 25 g	After 15 hours (TVC)	Listeria per 25 g
1.Fresh fish skin	136,000	negative	89,000	negative
2. Fresh fish flesh	20	negative	10	negative
3. Fish after filleting	10,100	negative	10,100	positive
4. Fish after deskinning	11,000	positive	5,100	negative
5. Fish after cutting machine 1	400	negative	49,000	negative
6. Fish before cutting machine 2	48,000	negative	37,000	negative
7. Fish after cutting machine 2	37,300	negative	57,000	negative

8. Fish after cutting machine 2	28,000	negative	25,000	negative
9. Fish after weighing	81,000	negative	70,000	negative
10. Fish after IQF	70,000	negative	33,000	positive

Table A-3. Temperature/Hydrogen sulphide producing organisms in fish processing plant located in Reykjavik, Iceland.

Description of product samples	In process			
	After 8 working hrs (Temp ^{o}C)	H_2S per 25 g	H_2S per 25 g	After 15 working hours (Temp ^{o}C)
1.Fresh fish skin		3,000	11,000	
2. Fresh fish flesh	0.7	<10	20	1.1
3. Fish after filleting	1	1,400	200	0.3
4. Fish after deskinning	2.9	13,000	500	0.5
5. Fish after cutting machine 1	4.5	460	7,000	1.4
6. Fish before cutting machine 2	4.3	4,100	600	2.4
7. Fish after cutting machine 2	3.8	2,500	700	
8. Fish after cutting machine 2	4.5	1,400	300	2.7
9. Fish after weighing	6.2	1,900	1,800	7.5
10. Fish after IQF		1,000	240	

Table A-4. Limiting Conditions for Pathogen Organisms Growth

Pathogen	min. a_w	min. pH	max. pH	max. % salt	min. temp.	max. temp.	O_2 need
Bacillus cereus	0.92	4.3	9.3	18	4 ^{o}C	55^{o}C	aerobe
Campilobacter jejuni	0.987	4.9	9.5	1.5	30 ^{o}C	45 ^{o}C	μ-aerophilic*
Clostridium botulinum, type A, Proteolytic B and F	0.935	4.6	9	10	10 ^{o}C	48 ^{o}C	anaerobe**
Clostridium botulinum, type A, non-proteolytic B and F	0.97	5	9	5	3.3 ^{o}C	45 ^{o}C	anaerobe**
Clostridium perfringens	0.93	5	9	7	10 ^{o}C	52 ^{o}C	anaerobe**
pathogenic strains of E. coli	0.95	4	9	6.5	7.0 ^{o}C	49.4 ^{o}C	F.anaerobe***
Listeria monocytogenes	0.92	4.4	9.4	10	- 0.4 ^{o}C	45 ^{o}C	F. anaerobe***
Salmonella species	0.94	3.7	9.5	8	5.2 ^{o}C	46.2 ^{o}C	F. anaerobe***
Shigella species	0.96	4.8	9.3	5.2	6.1 ^{o}C	47.1 ^{o}C	F. anaerobe***
Staphylococcus aureus – growth Staphylococcus aureus - toxin	0.83 0.85	4 4	10 9.8	25 10	7 ^{o}C & 10 ^{o}C	50 ^{o}C & 48 ^{o}C	F. anaerobe***
Vibrio cholerae	0.97	5	10	6	10 ^{o}C	43 ^{o}C	F. anaerobe***
Vibrio parahaemoliticus	0.94	4.8	11	10	5 ^{o}C	44 ^{o}C	F. anaerobe***
Vibrio vulnificus	0.96	5	10	5	8 ^{o}C	43 ^{o}C	F. anaerobe***
Yersinia enterocotilitica	0.945	4.2	10	7	-1.3 ^{o}C	42 ^{o}C	F. anaerobe***

* requires ltd levels of O_2 ** requires the absence of O_2

***grows either with or without O_2

Table A-5 Time/Temperature Guidance for Controlling Pathogen Growth and Toxin Formation

Potentially Hazardous Condition	Product Temperature	Maximum Cumulative Exposure Time
Growth of *Campylobacter jejuni*	30 °C – 34 °C >34°C	48 hrs 12 hrs
Germination, growth, and formation by Clostridium botulinum, type A, Proteolytic B and F	10 °C – 21 °C >21 °C	12 hrs* 4 hrs*
Germination, growth, and formation by Clostridium botulinum, type E, non - proteolytic B and F	3.3 °C – 10 °C 11 °C – 21 °C >21 °C	24 hrs 12 hrs 4 hrs
Growth of pathogenic strains of E. coli	7 °C – 10 °C 11 °C – 21 °C >21 °C	14 days 6 hrs 3 hrs
Growth of Listeria monocytogenes	-0.4 °C – 10 °C 11 °C - 21 °C >21 °C	2 days 12 hrs* 3 hrs*
Growth of Salmonella species	5.2 °C - 10 °C 11 °C - 21 °C >21 °C	14 days 6 hrs 3 hrs
Growth of Shigella species	6.1 °C - 10 °C 11 °C - 21 °C >21 °C	14 days* 6 hrs* 3 hrs*
growth and toxic formation by Staphylococcus aureus	7 °C - 10 °C 11 °C - 21 °C >21 °C	14 days 12 hrs* 3 hrs
Growth of Vibrio cholerae	10 °C 11 °C - 21 °C >21 °C	21 days 6 hrs* 2 hrs*
Growth of Vibrio parahaemoliticus	5 °C - 10 °C 11 °C - 21 °C >21 °C	21 days 6 hrs* 2 hrs*
Growth of Vibrio vulnificus	8 °C - 10 °C >21 °C	21 days 6 hrs 2 hrs
Growth of Yersinia enterocolitica	-1.3 °C - 10 °C 11 °C - 21 °C >21 °C	21days 6 hrs 2.5 hrs

* additional data needed

Table A-6. Checklist report of floor – level inspection for sanitation and pest control.

A.	**EXTERIOR AREAS**	**YES**	**NO**
1.	Absence of pest breeding		
2.	Absence of pest harborage		
3.	Garbage handling system		
4.	Garbage storage area		
5.	Garbage containers		
6.	Garbage container cleaning		
7.	Trash disposal		
8.	Paving and drainage		
9.	Weed control		
10.	Perimeter rodent control		
11.	Perimeter insect control		
B.	**BUILDING EXTERIOR**		
1.	Rodent proofing		
2.	Insect proofing		
3.	Bird proofing		
4.	Roofs		
5.	Lighting		
6.	Other structures		
C.	**BUILDING INTERIOR**		
1.	Walls		
2.	Floors		
3.	Ceilings		
4.	Cleanability		
5.	Plumbing		
6.	Ventilation		
7.	Lighting		
8.	Condensation		
D.	**STORAGE AREA**		
1.	Pest evidence absent		
2.	Empty container storage		
3.	Proper storage practice		
4.	Good house keeping		
Damaged Goods Storage			
1.	Segregation		
2.	Repackaging		
3.	Proper keeping of return goods		
4.	Adequate handling		
Refrigerated Area			
1.	Pest evidence absent		
2.	Condensation absent		
3.	Cleaning satisfactory		
4.	Other (specify)		
E.	**SEAFOOD PROCESSING AREAS**		
1.	Enclosed areas easily opened		
2.	Spaces under and behind equipment cleaned		

3.	Surface areas and facilities clean		
4.	No permanent seafood storage in processing areas		
F.	**INDOOR GARBAGE AND TRASH AREA**		
1.	Storage areas clean		
2.	Storage areas for receptacles adequately clean		
3.	Proper types of containers		
4.	Garbage containers regularly covered		
5.	Evidence of regular cleaning		
G.	**LOCKER ROOMS AND TOILET**		
1.	Adequate for current number of employees		
2.	Sanitary and in good repair		
3.	Self closing door and does not open to seafood areas		
4.	Adequate ventilation and no offensive odours		
5.	Area free of old rags, trash and clothes		
6.	Lockers regularly emptied and cleaned		
7.	Hand washing facilities clean, adequate and convenient		
8.	Adequate and appropriate trash receptacles		
H.	**OFFICE AREAS**		
1.	Clean		
2.	Regular trash removed		

Inspected by :..... Date:..... Time:.....

APENDIX 3

The following chlorine log will be used for chlorine monitoring information.
Table A-7. Chlorine Log

DATE	TIME	RESIDUE	LOCATION	SAMPLER INITIALS

Monitored By:..... Date: .....

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APPENDIX 4

The following sanitation monitoring report shall be used as a checklist for processing plant areas, which must be monitored.

Table A-8. Sanitation Monitoring Report

DESCRIPTION	COMPLIANCE		DESCRIBE	
	YES	NO	NON-COMPLIANCE	CORRECTIVE ACTION
Water:				
Fresh				
Bore hole				
Ice				
Food Contact Surfaces:				
Fish wheelbarrows				
Fish Bins				
Fish Totes				
Fish tables				
Header				
Butchering				
Cleaning Line				
Cross-Contamination:				
Water				
Product				
Employee Practices:				
Rest Rooms				
Hand Dip				
Break Area				
Employees Clothing				
Protection From Adulteration:				
Fresh Fish				
Butchering				
Freezing				
Packaging				
Storage:				
Container Storage				
Salt Storage				
Chemical Storage				
Brite Stack				
Employee Health:				
Illness				
Unprotected Abrasion				
Exclusion of Pests:				
Grounds				
Receiving Area				
Processing Area				
Storage Area				

Monitored By:..... Date:.....