

A MANUAL FOR TRAINING STAFF IN UGANDAN FISH PROCESSING PLANTS ON HYGIENE, SANITATION AND THE APPLICATION OF HACCP PRINCIPLES

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ABSTRACT

This manual is intended for use in the training of production staff in fish processing companies in Uganda. The companies are required to implement Hazard Analysis Critical Control Point (HACCP) quality control system in accordance with the Uganda fish quality assurance rules of 1998. The rules are harmonised with the European Union (EU) rules regarding the handling of fish and fisheries products on land and their implementation is a pre-requisite for export to EU markets.

The manual is in three sections:

Section A

Guidelines for compliance with the regulatory requirements on Good Manufacturing Practices (GMP). Emphasis is put on the training requirements of personnel in personal hygiene practices, clean up procedures, monitoring and control. This section targets the workers in the production line.

Section B

Guidelines to the application of HACCP principles to the processing of Nile perch products in a typical Ugandan fish-processing factory. A generic HACCP model plan is made for the management of the safety of fresh and frozen Nile perch fillets. This section is applicable to all the production staff as per the training needs identified at the end of this section.

Section C

Reference materials:

- 1) Requirements of the Ugandan regulations on GMP
- 2) Guidelines to monitoring and controlling essential areas of a sanitation program
- 3) An overview of the seafood hazards, biological, chemical, and physical

Five aspects of each hazard are considered:

General description (occurrence in nature, symptoms), epidemiology, risk assessment, disease control measures and application to the Nile perch processing. The information in this section is for the supervisory staffs and management in the plant.

These are included as appendices to the manual.

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1. INTRODUCTION

1.1 Agriculture in the national economy

Agriculture is the most important sector of the Ugandan economy employing 80% of the work force, and contributing 55% to the GDP. Coffee is the major export crop and others are tea, cotton, flowers, fruits and vegetables. The food industry is agro based; on dairy, fruit and vegetable processing with fish processing expanding rapidly since 1985 (Anon. 1997).

1.2 Fisheries in the national economy

Aquatic systems cover about 20% of the country's surface area comprising of five major lakes; Victoria, Albert, Kyoga, Edward, and George and about 160 small lakes in addition to rivers. These systems are important sources of fish.

Fish is still the cheapest source of high quality animal protein in Uganda and provides over 50% of animal protein consumption.

Fisheries provide employment for about 500,000 Ugandans (Anon. 1998a).

1.3 Fish processing and the export sector

Uganda fish production, estimated at 220,000 metric tons for 1995, consists mainly of capture fisheries. About 60% of the fish landed are marketed fresh while 40% is processed using the traditional methods of smoking, light or heavy salting and sun drying. Industrial processing of fish targets primarily Nile perch for the export market, and has become significant since 1988 when the first fish filleting and freezing plants were established.

The government has licensed twenty fish processing plants to process fish for exports, with an annual total quota of 60,000 tons of raw material to be processed. The trends in the exports of fishery products increased from 14,000 tons in 1996 to 35,000 tons in 1998. This is worth US\$ 100 millions (Anon. 1999). This is approximately 4% in terms of GDP exports, employment, and rates as second to coffee in terms of export earnings (MTI 1997).

The processing of fish for export requires high standards of hygiene in order to comply with international requirements. Internationally, fisheries products are required to be produced under the Hazard Analysis Critical Control Point (HACCP) quality system to assure safety. This system has been adopted worldwide. The EU through directive 91/493/EEC requires HACCP as a condition for trade in fisheries products from third world countries. Uganda has taken steps to adopt and implement the HACCP system.

Since 1994, training in HACCP has been initiated by the Food and Agriculture Organisation of the United Nations (FAO), the United Nations Industrial Development Organisation (UNIDO) and the World Health Organisation (WHO) of the United Nations and is ongoing for personnel of the competent authority (CA), responsible for food safety and fish plant management in some cases. Similar training

programmes have also been provided through bilateral development assistance from the governments of the Netherlands, Belgium and Japan. This training however has targeted only top and middle management in the companies. The fish factory employees working on the processing itself have been left out. They lack the basic knowledge of HACCP, which is crucial for its implementation. This possibly is the cause of the perpetual quality problem the industry has been experiencing in the international fish trade market.

Between January 1997 and March 1999, Ugandan fish has been banned from the EU markets three times mainly because of quality problems related to poor hygiene practices. Since then, there have been three EU audit missions to Uganda to audit the CA, Inspectorate and the companies. Their findings indicated:

- 1) Lack of a legal framework for the authority to enforce HACCP implementations
- 2) Non-existence of inspection guidelines for the fisheries inspectors
- 3) No evidence to show the activities of the CA in the fish processing establishment
- 4) Insufficient knowledge about HACCP principles by personnel responsible for monitoring the production process in the establishments (Anon.1998b).

The CA has put in much effort to correct the non-conformities and to harmonise quality management systems to comply with Ugandan legislation and EU directive 91/493/EEC.

The main issue now is to target the company staff responsible for controlling the production process and thus responsible for the implementation of HACCP and its prerequisites. The role of this group in ensuring food safety is crucial. They require basic training on HACCP and the pre-requisite requirements in order to fulfil their responsibility. This includes the knowledge of major sources of hazards, the controls required, the roles of critical control points in assuring food safety and the monitoring procedure.

Most HACCP pre-requisite requirements are included in the legislation. Hence, they are mandatory. Hygiene, clean-up- procedures, sanitation and monitoring are of great importance to fish processors as regards microbiological safety and will thus be an integral part of the HACCP training requirements.

It is from this viewpoint that the following objective is set.

1.4 Objective of the project

To develop a training manual on HACCP and its pre-requisites based on a typical fish company producing fresh and frozen Nile perch fillets in Uganda. The manual will be used in training production staff in the fish processing companies.

2. GOOD MANUFACTURING PRACTICES

There are regulations that have to be followed for fish products to be sold in the international market. The fish exported to the EU market should be prepared according to the regulations set by the EU countries.

The Ugandan regulations on fish products have been in place since 1998. The regulations are harmonised with the EU regulations. Fish companies meeting the Ugandan regulations also meet the EU regulations. (The guidelines to the regulations are in Appendix 1).

These regulations require that fish be processed by producers using the HACCP system. In this system, the control of fish starts on the beaches, through the factory up to the point of export out of Uganda.

The rules include a control of workers' condition of health, hygiene, and sanitation in the factory and regulatory agencies oversee its implementation. Sanitation and personal hygiene practices are difficult to control and yet they are crucial to the safety of fish products. It is therefore essential that workers are educated and trained in all aspects of the aforementioned practices. Guidelines to monitor the essential areas of the sanitation programs in an establishment are in Appendix 2.

The workers should be informed of the costs of not following good personal hygiene practices, for example to their jobs through closing of the factories by government, to the consumer (food poisoning), and to the country, as is now the case with Uganda with a ban on export to the EU.

Since bacteria mainly cause problems of safety in fish products, basic knowledge on these organisms is important for the workers.

2.1 Bacteria

These are small living organisms, which are invisible to the naked eye. Bacteria grow, increase in number, and some types of bacteria can produce toxins that cause food poisoning. They can get into fish products and harm the consumer. All fish handlers should take extreme care to keep this enemy from the fish factory and fish products.

2.1.1 Where do we find these bacteria?

1) The person

People have pathogenic bacteria in their noses, mouths, on the skin and in the faeces they excrete. Fish can be contaminated directly by the hands, sneezing or coughing or indirectly by sewage contaminated water. All water used in fish factories is therefore treated, for example, by chlorinating.

2) Insects

Several insects may transmit food poisoning bacteria to food. Flies and cockroaches present the greatest hazards because of their feeding habits and the places that they visit. Flies often land on animal/human faeces where they pick up large numbers of bacteria on their hairy bodies. In addition they defecate and vomit previous meals back onto fish as they feed. Careless use of insecticide often results in dead insects ending up in fish products.

3) On the fish body

When fish is brought to the factory there are bacteria on its body. For this reason, the processed fish products should not be allowed to mix with raw fish, during transportation or during storage in the factory.

4) Rodents

Rats and mice may excrete organisms such as Salmonellae. Contamination of fish products may occur from droppings, urine, fur/hair, and feeding. Food-contact surfaces on which rodents have walked must be disinfected before use. Food suspected of being contaminated by rodents must be destroyed.

5) Animals

Both domestic and wild animals are known to carry harmful bacteria on their bodies and in their intestines. Bacteria could be transferred to fish products from fur and feathers. Contamination is also possible from beaks, feet and droppings.

6) Dust

There are always large numbers of bacteria in dust and floating about in the air. Cleaning or any other activity that causes dust to be airborne should not be done at the time of processing fish.

7) Refuse and waste food

Waste products and unfit food must not be allowed to accumulate in fish processing areas. Care must be taken to avoid contamination of food from waste either directly or indirectly. Food handlers must wash their hands after placing refuse in dustbins. For this reason, all dustbins in the fish processing areas should be foot operated.

2.1.2 How do bacteria enter the factory?

Bacteria can enter the factory through one of the following ways:

- Fish brought into the factory
- Through packaging material
- Polluted water
- People who enter the factory
- Through unclean equipment

2.1.3 What are vehicles and routes of bacterial contamination?

Sometimes, harmful bacteria pass directly from the source to food, but bacteria are usually static and the sources may not be in direct contact with food. Ways in which bacteria can be transferred to food include:

1. By hands
2. On cloths and equipment
3. On hand-contact surfaces
4. On food-contact surfaces

2.1.4 What makes bacteria grow?

1. Temperature

The optimal temperature for the growth of pathogenic bacteria in fish is about 37°C (body temperature), although they can also multiply quickly at temperatures between 20°C and 50°C. Low temperatures (5°C) reduce growth of bacteria.

2. Food and moisture

High moisture foods are good for the growth of bacteria (e.g. meat, poultry, fish, and dairy products). Dry foods such as dried egg or milk powder do not provide the conditions necessary for growth. However, once water is added to the powder, any bacteria present will start growing. Other foods, which do not support bacterial growth, are those containing high concentrations of sugar, salt, acid or other preservatives.

3. Time

Given the right conditions on fish products, moisture and temperature, some bacteria grow rapidly. If there is sufficient time, some may multiply to such an extent that there are enough present to cause food poisoning. Therefore, fish products should not be kept under conditions that are optimal for the growth of bacteria.

2.1.5 What is food poisoning?

Food poisoning is an unpleasant illness that usually occurs within 1 to 36 hours of eating contaminated or poisonous food. Signs normally last from 1 to 7 days and include one or more of the following:

1. abdominal pain
2. diarrhoea
3. vomiting and
4. nausea

2.1.6 How does food poisoning occur?

Food poisoning may be caused by:

1. Bacteria or their toxins
2. Viruses
3. Chemicals such as insecticides and herbicides
4. Metals such as lead, copper and mercury

Bacterial food poisoning is by far the most common and in some instances may result in death. Other bacterial illnesses, which can be transmitted via food include typhoid, cholera and dysentery.

2.1.7 How do we reduce poisoning by fish?

By good hygiene. This includes:

1. Cleanliness
2. Protecting fish from contamination with bacteria, poisons and foreign bodies
3. Preventing any bacteria present in fish from growing to an extent that would result in poisoning or spoilage of the fish
4. Destroying any harmful bacteria in the fish by cooking or processing

2.1.8 The costs/effects of poor hygiene

1. Fish poisoning outbreaks and sometimes death
2. Fish contamination and consumers complaints
3. Pest infestations
4. Waste fish due to spoilage
5. The closure of fish factories by the authorities
6. Fines and costs of legal action taken because of not following the laws on hygiene or sale of contaminated fish to consumers
7. Legal action taken by persons who suffer from the food poisoning

All of these factors will contribute to a lowering of profits of the company; employees may lose their jobs. It is therefore in the best interests of everyone involved in the preparation and handling of fish to observe the highest standards of hygiene.

2.1.9 The benefits of good hygiene

1. Satisfied customers, and increased business for the company
2. Compliance with the law
3. Increased shelf-life of food
4. Good working condition, higher staff morale and lower staff turnover

All of these factors will contribute to higher profits and better earnings by the workers

2.1.10 What are the other causes of consumer complaints?

Foreign bodies, which often result in consumer complaints, include:

1. Pieces of metal – often found after maintenance and repair work, such as bolts, nuts, wire, and staples
2. Cardboard, string and plastics often introduced from packaging
3. Rodents, rodent hairs, insects, feathers and droppings
4. Sweet wrappers and cigarette stubs
5. Items from personnel such as earrings, fingernails, hair, buttons
6. Glass
7. Cleaning compounds
8. Wood splinters
9. Grease and oil
10. Flaking paints from walls or rust on equipment

3. PERSONAL HYGIENE PRACTICES WORKERS SHOULD KNOW

3.1 Introduction

It is not only the factory premises that should be kept clean and in a hygienic condition. The workers must keep themselves clean and practice good personal hygiene. Some of the bad habits of workers that are not allowed in the factory are:

3.1.1 Smoking

- Smoking inside the factory is a bad habit
- The cigarette ash could get onto the fish fillet
- The cigarette butts could be mixed with fish
- While smoking you touch your lips and transfer bacteria to your fingers
- Saliva can end up on the working tables and on the fish products

Therefore never smoke inside the fish-processing factory. "No Smoking" notices are displayed in areas where smoking is not allowed.

3.1.2 Spitting/sneezing

Some workers sneeze, spit, and clean their nose, inside the factory working area. These are bad habits because:

- Bacteria from the mouth and nose will get into the fish
- Mouth, nose, and ears are places where plenty of bacteria are found. Forty percent of adults carry Staphylococci bacteria with them. Workers should not touch their mouth, nose, or ears while working.

3.1.3 Health conditions

1. If you are suffering from a disease you should get treatment immediately and inform your supervisor that you are suffering from a disease
2. Once you are cured, you should present a medical certificate before reporting back to work
3. Only healthy workers are allowed to work in the processing area for fish
4. If anybody suffers from diarrhoea, vomiting, food poisoning, or fever, he/she must stay out of the factory
5. Workers who live with such patients must check with the doctor and get a medical clearance before entering the factory
6. Workers are required to inform their supervisors if they suffer from any illness or have any of these signs: Dripping nose, ears, eye or mouth

3.1.4 Eating/ drinking/chewing

1. Some workers eat and drink inside the factory working area. This is a bad habit, which is not allowed. Food and drink must only be consumed in the staff restaurant.
2. Some workers chew coffee and gum while at work. This is not allowed inside the factory.

3.1.5 Working clothes

1. These are not to be taken home. They get dirty on the way home. They are for use only inside the factory.
2. Clothes/aprons may be marked: no. 1 and no 2 ,or in different colours
3. Aprons no. 1 should be worn inside the factory working area. Apron no. 2 should be worn only outside on the factory premises.
4. The aprons you wear in the factory should be made of rubber or plastic material and be easy to clean. They are to be cleaned every day or whenever they get dirty and should be dried.
5. Protective headgear: In the fish packing area and in other places where management feels necessary, the workers should wear hairnets.
6. Working clothes must not be put on the processing tables or equipment because bacteria from the clothes can get on to the working surfaces and then into the fish.
7. Shirt, blouse and sweater sleeves must be rolled up past the elbow. If not, they may come into contact with the fish and contaminate it with bacteria.

3.1.6 What makes clothes dirty and contaminated with bacteria?

1. In buses, trains or in any public transport system, there are many people dressed in dirty clothes, and when you are squeezed inside the crowded buses, your clothes will get dirty.
2. While travelling in a bus or train you tend to hold onto bars, for support in the vehicle. From these bars, dirt and germs might get onto your hands.
3. When you are travelling on the road, dust and dirt on the road might dirty your clothes.
4. You might sweat when you walk in the hot sun.
5. Whenever you have to wait for a while during travelling, you tend to lean on some object near by, and this will transfer dirt and germs to your clothes.
6. During rainy days when you are travelling on the road, the muddy water may get on to your clothes, making them dirty. When you enter the factory working area without wiping your feet well, it will also bring dirt and germs into the factory.
7. There are many other ways that clothes get dirty when you travel to work. It is our duty to avoid them and not bring bacteria into the factory.
8. Injuries (e.g. wounds, boils, cuts, sore and skin infection)
9. When there is a wound, boil or any of the above in your hand you should not touch the fish without covering it. These places are good for bacteria.
10. Rubber cover/water proof material should be used to cover the wounds or boils.
11. The colour of this rubber cover should preferably be green or blue so that it can be identified if it falls into the products by mistake.
12. Report immediately to your supervisor.

3.1.7 Hair/beards

1. When you are handling fish, you should not touch or scratch your hair/beard or body. It may result in hair/dandruff dropping onto the product. Hair also carries lot of bacteria. Workers are required to cover their hair with a net, while working. Hair styling and combing should be carried out only in the dressing rooms.
2. Beards must always be kept short, clean and protective cover worn if the management considers it necessary.

3.1.8 Jewellery

When you are working inside the factory, you should not wear items such as earrings, necklaces, wristwatches and bangles. These might slip off and fall into the fish products. Perfumes and nail polish should not be applied. Wedding rings may be allowed. It depends on the management.

3.2 Good personal hygiene and habits

In all factory premises, there should be adequate rooms provided for changing clothes and keeping personal items.

3.2.1 Good habits

Personal clothes and shoes should not mix with working clothes

1. Remove them in the change room
2. Wash your hands well and disinfect
3. Get the factory working clothes, aprons, dresses, shoes and head gear
4. Dress in them
5. Clean your hands again and disinfect
6. Do not touch any other thing, get to your work place and do your work

3.2.2 Hand washing

1. Hands must be washed regularly and kept clean at all times
2. Hands must be washed with soap and disinfectants
3. When you go to the canteen and come back to the working area, your hands might get dirty, especially if you touch money. Your hands should be well cleaned before entering your workstation
4. All the taps should be operated by feet. This will avoid the workers touching the tap after washing hands.
5. Once you have cleaned your hands you should use only disposable

3.2.3 Toilets

1. Before you go the toilet, remove your head cover, apron, shoes and gloves. Once you come out of the toilet, you should clean your hands with soap, hot water and use a disinfectant, put on the uniform, and clean your hands again with disinfectant and enter the working area.
2. When your duty is changed, e.g. from raw material area to finished product area, or in between breaks and shifts you should clean your hands.

3. Workers are not allowed to loiter in the toilet areas. The toilet areas are contaminated with sewage bacteria that can be transferred to the processing area and fish products.

3.2.4 Foot dips

All workers are supposed to pass through the foot dips wherever they are constructed. This helps to prevent transferring bacteria to the processing areas. Cleanliness in the factory and workers' health conditions are matters to be considered on a daily basis.

3.2.5 Method of training and monitoring

Should be simple and practical:

1. It may take the form of a simple advice to an individual worker
2. Use of posters e.g. "no smoking", "no eating" posters can act as reminders
3. Instructions may be given to the workers on leaflets

The supervisory staff is responsible for ensuring that all employees follow proper hygienic practices. Observation of personnel with respect to these practices and the use of a checklist to assess the practices and evaluate the effectiveness of the training methods can achieve this.

A sample checklist is given in appendix 6.

4. CLEAN UP PROCEDURE

4.1 Introduction

Cleanliness of workers, equipment, and premises is very important to all stages in the fish processing because:

1. Fish must be protected from contamination by pathogenic micro-organisms that cause disease in consumers
2. Fish must be protected from spoilage organisms that can cause deterioration in the quality of fisheries products
3. Good standards of cleanliness minimise the risk of rodent and insect infestation.

4.1.1 Why do we clean?

Cleanliness minimises the risk of cross contamination between fish products and the processing environment. Waste fish product material left on equipment and surfaces can act as a primary source of contamination, since it serves to harbour large populations of micro-organisms.

4.1.2 How to proceed in cleaning?

- a) Preparatory work
 - Remove remaining fish, carcasses, containers, filleting knives and other loose items

- Dismantle conveyors and other machines so that it is possible to clean all parts where bacteria can hide
- Cover all electrical installations and other sensitive equipment to protect against water and the cleaning chemicals
- Use brush and scrapers to remove debris and rinse with cold or hot water. Hot water should be used where there is a lot of fat.

b) Cleaning step

Remove all undesirable materials (off cuts, scales, micro-organisms, dirt, slime, oil, and solids) from the surfaces with the aid of a detergent.

c) Sanitising step

Sanitising (or disinfecting) is the part of the operation where surfaces and equipment are rendered "microbiologically clean". Sanitisers serve to destroy living micro-organisms.

4.1.3 A complete cycle of a clean up procedure

1. Remove remaining fish products, clear the area of bins, and other receptacles
2. Dismantle the equipment to expose surfaces to be cleaned
3. Cover sensitive installation to protect against water
4. Pre rinse. Remove product residues and other loose material by sweeping, scraping, brushing or by flushing with water
5. Apply cleaning agent and use mechanical energy as required (e.g. pressure and brush)
6. Rinse thoroughly with water to completely remove the cleaning agent after the appropriate contact time
7. Control of cleaning by visual inspection
8. Disinfecting by chemical disinfectant or heat
9. Finally rinsing of the disinfectant with water after appropriate contact time
10. After the final rinse the equipment is reassembled and allowed to dry
11. Control of cleaning and disinfecting

A summary of these steps is found in table 1.

Table 1: Summary of the cleaning steps.

Step 1	RINSE (with cold water) PURPOSE: To remove visible solids To remove large number of micro-organism
Step 2	SCRUB (with warm water and detergents) PURPOSE: To remove most remaining micro-organism
Step 3	RINSE (with cold water) PURPOSE: To remove detergents and micro-organism
Step 4 SANITISING PHASE	SANITISE PURPOSE To kill residual micro-organism
Step 5	RINSE. PURPOSE: To remove sanitises

4.1.4 When to clean

There should be a regular and thorough program for cleaning at least at the end of each batch of production, between shifts or once a day. A guide to a day task in a fish factory could be as follows:

A. Beginning of day:

1. Rinse all working surfaces, sinks and tanks with low-pressure cold potable water as a precaution to remove any cleanser from the previous day's clean-up
2. Prepare hand and foot dips to proper disinfectant strength based on the manufacturers recommendations
3. Complete the daily clean up report and undertake any actions required.
4. Check processing water chlorine level, to ensure it contains approximately 1 ppm chlorine

B. During operations:

1. If they are in continual use, rinse plastic fillet pans and aluminium freezer trays in clear water immediately after use
2. In areas where there is significant concern regarding specific bacteria or where pans are not in use, always clean and disinfect pans after each use
3. Periodically rinse all working surfaces with low-pressure potable cold water to remove any gross debris
4. Check and change hands or foot dips, if necessary
5. Check and change plastic fillet pan and aluminium freezer tray dip and wash tanks, if necessary.
6. Check and adjust processing water chlorine levels where necessary
7. Clean gray containers and tote boxes with detergents, using high-pressure water, or other means of agitation
8. Adhere to personal hygiene rules

C. During coffee/rest and lunch breaks:

1. Rinse floors, working surfaces, and all equipment with low pressure potable cold water to remove any gross debris
2. Change all hands and foot dips
3. Change plastic fillet pan dips and wash tanks

D. Between shifts within a day:

1. Remove all fish from processing equipment.
2. Rinse floors, working surfaces, and, wherever practical, all equipment with low pressure potable cold water to remove any gross debris.
3. Change all hand and foot dips.
4. Change plastic fillet pan dips and wash tanks.

E. End of day:

1. Processing equipment:
2. Remove all fish from processing equipment
3. Follow proper cleaning and disinfecting procedure. Clean areas such as floors, walls, doors and chill room
4. Plastic fillet pans:
5. Remove any gross debris using low-pressure potable cold water
6. Soak pans for 15 to 30 minutes in a wash tank charged with a detergent (strength as recommended by manufacturer) in approximately 60°C water; scrub, if required
7. Rinse or dip with clear potable water
8. Dip pan in a disinfectant
9. Place pans upside down, without bedding one inside the other, in a clean area off the floor, to allow for drainage and air drying

F. Weekly:

1. It should be recognised that daily cleaning even if very good will not be perfect. For this reason, once per week, or on a rotating basis throughout the week, each area of the plant should be given special attention and a more thorough cleaning done. This should not, however, be seen as a rationale for doing less than a thorough job on a daily basis.

4.1.5 Control of cleaning

2. All cleaned surfaces should be visibly clean
3. All surfaces by touching, are free from food residues, scales, and other materials, and by smelling are free from undesirable odour
4. The concentrations, pH-values of cleaning agents, temperature, if hot cleaning is used and contact time should be monitored and registered
5. pH-measurements of rinse water should be used to ensure that the cleaning agent has been removed so that it will not interfere with the disinfectant.

5. HAZARD ANALYSIS CRITICAL CONTROL POINT

5.1 Background

Hazard Analysis Critical Control Point (HACCP) was developed in the early 1970s by the Pillsbury Company for the manufacturing of safe food for the United States space program. The original program, based on product testing could not assure absolute safety, which was required. A preventive system that included testing points anywhere from raw material to the packaged product was needed.

The engineering system called Failure Modes and Effect Analysis (FMEA) was used as the basis for developing the HACCP system.

FMEA answers questions such as:

1. What can go wrong at each stage in an operation?
2. What are the causes and effects?
3. How can they be prevented and controlled?
4. What action is required when it does go wrong?

HACCP has been applied in the food industry since the 1970s and has become internationally accepted as the most effective system for production of safe foods. In December 1997, HACCP became a requirement for seafood processors in the EU.

5.1.1 Benefits of the HACCP approach.

A number of benefits for consumer, industry, and government can be realised by the application of the HACCP system as a management tool for food safety control in food processing and manufacturing. The essential benefits are:

1. Applicability to the entire food production chain
2. Increased confidence in product safety
3. Cost-effective control of food-borne hazards
4. Emphasis moved from retrospective quality control to preventive quality assurance
5. A common approach to safety issues
6. Facilitation of international trade
7. Provision of documented evidence of process control
8. Evidence of compliance with specifications, codes of practice and/or legislation

5.1.2 Problems with HACCP implementations

The principles of HACCP are applicable to all sectors of the food industry including small-scale enterprises. However, some specific problems are faced by the small-scale enterprise in applying the HACCP system. The small-scale fish processing companies in Uganda may face similar problems. The guidelines below are to help the companies overcome such problems.

Insufficient knowledge of HACCP.

Staff of a small company can gain a good understanding of HACCP principles by reading books on HACCP and attending specific training sessions on HACCP.

1. Insufficient technical expertise.

A small company may not have the full range of skilled technical experts (particularly specialists e.g. microbiologists, food chemists, technologists, packaging experts) readily available to contribute to the HACCP study. As such, they are not likely to have all the detailed specialist technical data required.

Where such expertise is not available, expert advice can be obtained from other sources, which could include written codes of practice, industry guidelines, good manufacturing practice guidelines, published data, and, consulting services.

2. Insufficient technical resources.

The implementation of the HACCP plan can require various technical resources and equipment.

Any equipment to be purchased should be identified by the HACCP study as relevant, simple to use, quick and affordable. Small enterprises should only buy equipment recommended by the study.

3. Concentration of functions.

In many small companies, multiple responsibilities can be concentrated in the hands of one or two people, resulting in some difficulties in assembling the HACCP team and carrying out a HACCP study.

Although a HACCP study requires a multi-disciplinary team comprising a number of individuals with specific skills, it is possible that such a range of skills are covered by fewer people in a small company; it may therefore be appropriate for one person to fulfil more than one role. This is acceptable if all relevant information is available and the team is capable of using such information to ensure the correct identification and control of hazards.

This concentration of functions may cause difficulties with the inclusion of HACCP work in the daily timetable for the employees of small companies. In this case, the implementation of HACCP should be achieved, either by allocating time within the current company structure or by making additional resources available.

Irrespective of whether the company staff carries out the HACCP study alone or with the help of a consultant, all information relevant to the particular study (e.g. raw material lists, flow diagram, product formulation time/ temperature of processing) should be prepared before the study starts.

5.2 HACCP principles and application

The Hazard Analysis Critical Control Points (HACCP) concept is a systematic, scientific approach to process control. It is viewed as a means of preventing the occurrence of health and safety hazards in plants producing fish and fisheries products. It does this by ensuring that controls are applied at any point in the fish production system where hazardous situation may occur. These hazards may include biological, chemical, or physical adulteration of fish products.

The Uganda Fish Quality Assurance Rules (1998) mandated that HACCP be implemented as a system of process control in all registered fish-processing establishments. As part of the effort to help establishments prepare plant specific HACCP plans, a generic HACCP model plan for the processing of Nile perch products is prepared in this manual as a guide.

In addition to the generic model, background information on HACCP is included to assist an establishment in conducting a hazard analysis and developing a plant specific plan.

The Uganda regulation includes specific requirements on the GMP, (Appendix 1). These requirements should be in place before a HACCP system is implemented.

5.2.1 Principles of HACCP

The foundation of HACCP can be found in the seven principles that describe its functions.

Principle No. 1: Conduct the Hazard Analysis. Prepare a list of steps in the process where significant hazards occur, and describe the preventive measures.

Principle No. 2: Identify the Critical Control Point (CCPs) in the process.

Principle No. 3: Establish critical limits for preventive measures associated with each identified CCP.

Principle No. 4: Establish CCP monitoring requirements. Establish procedures for using the results of monitoring to adjust the process and maintain control.

Principle No. 5: Establish corrective action to be taken when monitoring indicates that there is a deviation from an established critical limit.

Principle No. 6: Establish effective record keeping procedures that document the HACCP system.

Principle No. 7: Establish procedures to verify that the HACCP system is working correctly.

5.2.2 Definitions

Some definitions of commonly used HACCP terms are included below to clarify some of the terms in reference to HACCP, hazard analysis, model development, and the development of the HACCP plan.

1. Corrective action: Procedure to be followed when a deviation occurs
2. Criterion: A standard on which a judgement or decision can be based
3. Critical Control Point (CCP): A point, step, or procedure in a food process at which control can be applied and as a result a food safety hazard can be prevented, eliminated, or reduced to acceptable levels.

4. **Critical limit:** The maximum or minimum value to which a physical, biological, or chemical hazard must be controlled at a critical control point to prevent, eliminate or to reduce to an acceptable level.
5. **Deviation:** Failure to meet a critical limit.
6. **HACCP:** Hazard Analysis and Critical Control Points. A process that identifies specific hazards and preventive control measures to ensure the safety of food.
7. **HACCP plan:** The written document that is based upon the principles of HACCP and that delineates the procedures to be followed to ensure the control of a specific process or procedure.
8. **HACCP system:** The HACCP plan in operation, including the HACCP plan itself.
9. **Hazard (Food Safety):** Any biological, chemical, or physical property that may cause a food to be unsafe for human consumption.
10. **Hazard Analysis:** The identification of any hazardous biological, chemical, or physical properties in raw materials and processing steps, and assessment of their likely occurrence and potential to cause food to be unsafe for consumption.
11. **Monitor.** To conduct a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification.
12. **Preventive measures.** A procedure consisting of any number of separate, distinct, and ordered operations. These are directly under the control of the establishment and used in the manufacture of a specific product or a group of two or more products where all CCPs, such as packaging, may be applied to one or more of those products within the group.

5.2.3 Development of the plant specific HACCP plan.

The National Advisory Committee on Microbiological Criteria for Foods (NAMCF 1998) has defined 12 steps (five preliminary steps listed below and the seven principles above) in developing a HACCP plant specific plan.

Preliminary steps:

4. Assemble the HACCP team.
5. Describe the food and method of distribution.
6. Identify the intended use and consumer of the food.
7. Develop a flow diagram, which describes the process.
8. Verify the flow diagram.

Then apply the seven principles.

5.3 Application of the 12 steps by NAMCF.

5.3.1 Preparing the HACCP team and guidelines to its composition.

The HACCP team should be composed of a HACCP trained individual and other member(s) who are familiar with the product and the process as it is conducted in your plant. There is no set number of participants. Your establishment should determine this.

All team members should receive at least a basic introduction to HACCP. Training can be formal classroom training, on-the-job training, information from college courses, and/or HACCP books or manuals like this one.

Some of the relevant textbooks and journals are included in the list of references.

5.3.2 Product Description.

The Product Description step is used to describe the fish product that is produced in the establishment and the method of distribution. This information is important when determining whether a significant hazard exists and how/where it can be controlled. The description(s) answers the following questions (Table 2):

1. Common name of product
2. How it is to be used (the intended use of the fish product by the end users or consumers). The intended consumers may be the public or a particular segment of the population such as infants, the elderly, immune compromised individuals
3. Type of packaging used (plastic bag/vacuum packed)
4. Length of shelf life, and appropriate storage temperature
5. Where it will be sold (retail/wholesale)
6. Labelling instructions (keep frozen/keep refrigerated, thawing and cooking instructions, safe food handling)
7. Special distribution controls (keep frozen/keep refrigerated)

In this model, the purpose is to control the processing conditions of fresh/frozen Nile perch fillets, and obtain products free from public health risks. Microbiological, chemical and physical hazards are considered. Spoilage micro-organisms are not considered.

Table 2: Product Description Form.

1. Common Name?	Frozen/Fresh Nile perch fillets
2. How it is to be used?	For home consumption.
3. Type of package?	Fresh: 6 kg Styrofoam boxes; Frozen: 1 ^o polyethylene bags for individual fillets; 2 ^o 6 kg waxed carton boxes.
4. Length of shelf life/ Storage temperature	Fresh: 2 weeks at 0°C; Frozen: 18 months at -18°C;
5. Where will it be sold? Consumers? Intended use?	Local/International markets Retail/Wholesale Public To be properly cooked before consumption.
6. Labelling instructions?	Keep Refrigerated/Frozen.
7. Is special distribution control needed?	Keep Refrigerated/Frozen.

5.3.3 Process Flow Diagram

The flow diagram must cover all the steps in the process, which are directly under the control of the establishment. It can also include steps in the fish processing chain, which are before and after processing. The flow diagram should be simple, consisting of words, not engineering drawings. In this model study, the flow is from the establishment reception up to dispatch within the company premises.

5.3.4 Source of fish to the factories.

Nile perch is caught in deep offshore waters of Lake Victoria, iced on board, transported to the beaches, and auctioned. The fish companies/suppliers purchase the fish and transport it in insulated trucks to the processing establishments.

There are two sources of fish to the fish companies:

1. The fish companies can purchase the fish directly from the fishermen at the beaches;
2. The suppliers/fishermen can deliver the fish directly to the fish company establishment in insulated trucks or at the establishment beaches in insulated boxes on board. From either source, the fish pass through the reception in the establishment.

An overview of the processing steps is in a flow chart (Table 3).

Table 3: Process flow chart for fresh and frozen Nile perch products

Process steps	Activities
Fish Purchasing	Directly from the suppliers at the beaches.
Receiving	At the establishment.
Washing	Individually under high-pressure potable water.
Grading/Sensory checks	Sorting according to size and quality.
Iced storage.	Insulated rooms at 0°C
Filleting + Rinsing	Fillet by hand; Rinse with potable water.
Skinning + Rinsing	Skin by hand, Rinse with potable water
Grading	By hand
Fresh product	Frozen product:
Trimming	Trimming
Weighing	Weighing
Super chilling	Freezing
Packing	Packing
Storage at 0°C	Storage at -35°C
Dispatch at 0°C	Dispatch at -18°C
	For different products
	Trim by hand
	By hand on electronic scales.
	Gyro/Blast freezer
	Blast/Plate freezer
	Pack by hand
	Store in chilled room at 0°C Cold stores at -35°C
	Insulated and refrigerated trucks at 0°C and 18°C respectively.

5.3.5 Verify process flow diagram

Member(s) of the HACCP Team should use the drafted flow diagram and walk through the actual process as it occurs and make any adjustments necessary.

5.3.6 Hazard Analysis/Preventive Measures

The hazard analysis/preventive measure take the steps listed in the process flow diagram and identifies where significant hazards could occur and describe the preventive measures, if they exist. The hazard must be of such a nature that its prevention, elimination, or reduction to an acceptable level is essential to the production of a safe product. Hazards that are not significant or not likely to occur will not require further consideration.

The hazard analysis consists of asking a series of questions, which are appropriate to the specific process and establishment. It should question the effects of a variety of factors on the safety of a product. Factors must be considered that may be beyond the control of the processor. During the hazard analysis, safety concern must be differentiated from quality concerns. Each step in the process flow will be evaluated to determine if any significant hazards should be considered at that step. Examples of questions to be considered have been included as Appendix 4.

The potential significance of each hazard should be assessed according to risk and severity. Risk is usually based on a combination of experience, epidemiological data, and information in the technical literature. Severity is the seriousness of the hazard.

Preventive measures if they exist must be identified. A preventive measure is a physical, chemical, or other measure, which is used to control an identified food safety hazard.

For this process, the hazard analysis is done through a literature survey on the biological, chemical and physical hazards of concern in seafood. The hazards were analysed in the Nile perch products based on the analysis on personal experience and knowledge of the process (Appendix 3).

Potential hazards considered in the hazard analysis included (Table 4):

1. Biological hazards

Indigenous pathogenic bacteria. Bacteria in this group can be part of the natural microflora of the Nile perch as they are in the harvest waters e.g. *V. cholera*, *V. parahaemolyticus* and *C. botulinum*.

Non-indigenous pathogenic bacteria. This can result from catching or harvesting in polluted waters and non-hygienic handling throughout the processing chain. They include *S. aureus*, *Salmonella* spp., *E. coli*, *V. cholera*, *Shigella*.

Other biological hazards considered in the hazard analysis were: Viruses, parasites, and species related hazards e.g. histamine.

2. Physical hazards

Here the presence of physical hazards was found less critical. Mostly there are extra checks to remove foreign objects and bones from fillets manually from the products during the processing chain. Regular maintenance of equipment controls physical hazards that can result from parts that could break off and constitute metal inclusion hazards.

3. Chemical hazards

- Residues of cleaning and disinfecting agents are controlled as part of the GMP controls.
- Environmental contaminants e.g. pesticides (organo-chlorinated substances) illegally used to kill fish. Control of this hazard is considered important though there is no epidemiological evidence associated with it. The control will help build data/results that can be used as evidence against or for the current perception by the market regarding this hazard.

Detailed analysis is in Appendix 3.

Table 4: Hazard Analysis Preventive Measure Form

Process Step:	HAZARDS: Biological (B) Chemical (C) Physical (P)	Preventive measures This is controlled by GMPs.	Example of how a hazard is introduced. (This column is for illustrative purpose only and not to be included in a plant specific HACCP plan)
PURCHASING RAW MATERIAL	(B) Contamination, growth of pathogenic bacteria, e.g. Salmonella, S. aureus, V.cholerae, E. coli (C) Pesticide e.g. organo- phosphates	(B) GMP; Hygiene in handling; Txt control. (C) Purchase from registered fishermen/suppliers with valid documents.	(B) Cross contamination from polluted water Txt abuse (C) Use of pesticides to kill fish.
ICED TRANSPORTATI ON	(B) Contamination and growth of pathogenic bacteria.	(B) GMP: Use ice from potable water, proper icing.	(B) Use of contaminated ice; poor icing.
RECEPTION (ESTABLISHMEN T)	(C) Fish killed with pesticides.	(C) Verify source of fish.	Purchasing fish from illegal fishermen/suppliers.
WASHING	(B) Contamination with pathogens	(B) GMP: Use potable water.	Use of non-potable water.
GRADING/SENSO RY CHECKS	(B) Growth of pathogens	(B) GMP: Txt control.	Txt abuse.
ICED STORAGE	(B) Contamination and growth of pathogens, e.g. E. coli, S. aureus, Salmonella and Shigella.	(B) GMP: Use ice from potable water. Ice adequately.	Use of ice from non-potable water; Poor icing.
FILLETING + RINSE	(B) Contamination and growth of pathogens e.g. S .aureus, E. coli, and Salmonella spp., Shigella. Cross-contamination from viscera to fillets.	(B) GMP: Personal hygiene training. Use potable water. Training of filleters.	Poor personal hygiene; Use of non-potable water. Poor filleting results into cutting viscera and cross contamination.
SKINNING + Rinsing	(B) Contamination and growth of pathogens.	(B) GMP: Personal hygiene training, Use of potable water.	Cross contamination from personnel and equipment; Use of non-potable water;
GRADING	(B) Contamination and growth of pathogens.	(B) GMP: Personal hygiene training; Txt control.	Cross contamination from personnel; Txt abuse.
TRIMMING	(B) Contamination and growth of pathogens.	(B) Personal hygiene; Txt control.	Cross contamination from personnel; Txt abuse.
WEIGHING	(B) Contamination and growth of pathogens.	(B) Personal hygiene; Txt control.	Cross contamination from personnel; Txt abuse.
SUPER CHILLING	Not identified.	-	-
FREEZING	Not identified.	-	-
PACKING	(B) Contamination and growth of pathogens.	(B) Personal hygiene training; Txt control.	Cross contamination from personnel; Txt abuse.
STORAGE AT 0°C	Growth of pathogens.	(B) Txt control.	Temperature abuse.
STORAGE AT - 35°C	Not identified	-	-
DISPATCH	Not identified.	Txt abuse	Delayed loading.

5.3.7 CCP Determination.

The Critical Control Point (CCP) determination step is used to identify the critical control points in the process (Table 5). All significant hazards identified in the hazard analysis must be addressed. Identification of each CCP is facilitated by the use of HACCP Decision Tree (Appendix 5). The Decision Tree asks a series of four yes or no, questions to assist in determining if a particular step is a CCP for a previously identified hazard. These four questions are listed at the top of the CCP determination form. Use this as a guide when determining if an identified significant hazard is a critical control point. CCPs must be carefully developed and documented, and must be for product safety only. Different facilities preparing the same product can differ in the risk of hazards and the points, steps, or procedures, which are CCPs. This can be due to differences in each facility such as lay-out, equipment, selection of raw material or the process that is employed.

Table 5: CCP determination form

PROCESS STEP:	HAZARDS	Q1. DO PREVENTIVE MEASURES EXIST FOR THE IDENTIFIED HAZARDS? If no=not a CCP- identify how and where this hazard will be controlled. If yes= move to next question.	Q2. DOES THIS STEP ELIMINATE OR REDUCE THE LIKELY OCCURRENCE OF A HAZARD TO AN ACCEPTABLE LEVEL? *If no=move to the next question. *If yes=CCP	Q3. COULD CONTAMINATION WITH IDENTIFIED HAZARD(S) OCCUR IN EXCESS OF ACCEPTABLE LEVELS OR COULD THESE INCREASE TO UN-ACCEPTABLE LEVELS? *If no=not a CCP. *If yes=CCP	Q4. WILL A SUBSEQUENT STEP ELIMINATE HAZARD (S) OR REDUCE THE LIKELY OCCURRENCE TO AN ACCEPTABLE LEVEL? *If no=CCP. *If yes=not a CCP	#CCP
Purchasing fish at the beaches	(B) Contamination with pathogens. (C) Fish killed with pesticides.	(B) No; GMP: Buying fish from approved landings (C) Yes	(C) Yes			CP CCP. 1
Receiving fish at the factory	(B) Contamination and growth of pathogens. (C) Fish killed using pesticides.	(B) No. GMP: Hygiene and sanitation Txt control during transportation (C) Yes.	(C) Yes			CP CCP. 2
Filleting	(B) Cross contamination of pathogens from the viscera, water.	(B) No. Training in filleting methods. Use of potable water, Txt control.				CP.
All processing steps	(B) Cross contamination and growth of pathogens.	(B) GMP: Training in personal and plant hygiene.				CP.
Dispatch						CP.

Key: CP., Control is through GMP monitoring and control. CCP: GMP monitoring cannot affect control.

In this model study, the CCPs identified are for illustrative purposes only. Your individual process will determine the CCPs. The CCPs were determined with the CCP decision tree as described in the Codex Alimentarius (FAO and WHO 1993).

5.3.8 HACCP plan

The plan can serve as a useful guide to monitor critical points (Table 6). It is essential however that the unique conditions within your facility be considered during the development of the specific plan. The first three columns on the form are transferred from the CCP Determination Form. The fourth column is used to establish critical limits for preventive measures associated with each identified CCP.

Table 6: HACCP plan form.

PRODUCTS FRESH/FROZEN NILE PERCH FILLETS							
PROCESS STEPS:	HAZARDS: Biological Chemical Physical	CCP	CRITICAL LIMIT	MONITORING PROCEDURE / FREQUENCY / PERSON RESPONSIBLE.	CORRECTIVE / PREVENTIVE ACTION/ PERSON RESPONSIBLE.	HACCP RECORDS	VERIFICATION PROCEDURE S/ PERSON RESPONSIBLE.
PURCHASING FISH/RAW MATERIAL	(C) Fish killed with pesticides.	CCP 1	All fish from approved suppliers and with valid accompanying documentation	Verify documents (Purchasing officer). For every batch, sample for pesticide residues. (Lab. technician).	Reject supply (Purchasing officer). Withhold, alternative market, incinerate. (Management).	Document verification records. Laboratory analysis reports.	Verify documents for each supply. Verify results with guidelines.
RECEIVING FISH IN THE FACTORY	(C) Fish killed with pesticides.	CCP 2	All fish from approved suppliers and with valid accompanying documentation.	Verify documents For every batch. Sample for pesticide residues. (Lab. technician)	Reject supply (Purchasing officer). Withhold, alternative market, incinerate. Management).	Document verification records. Laboratory analysis reports.	Verify documents for each supply. Verify results with guidelines.

In this model plan, the tolerance limits for fish killed using pesticide is zero. Therefore, any fish delivered without any valid documentation is suspected as killed with pesticide and should be rejected.

Each CCP may have one or more preventive measures that must be properly controlled to assure prevention, elimination, or reduction of hazards to acceptable levels. Critical limits may be derived from sources such as:

1. Regulatory standards and guidelines
2. Literature surveys
3. Experimental studies and
4. Subject matter specialists or technical experts

5.3.9 Monitoring

Monitoring is essential to a food safety management by tracking the HACCP system operations. If monitoring indicates levels above critical limit, then immediate corrective actions should be taken.

1. Monitoring provides written documentation for use in verification of the HACCP plan.
2. All records and documents associated with CCP monitoring must be signed dated and the time recorded by the person doing the monitoring.

This model study effectively identified only two CCPs, the purchasing of fish at the beaches and reception in the factory. The monitoring procedure is as in the HACCP plan. An example of the monitoring form is in Appendix 8.

The rest of the production steps are identified as CPs. The important factors to monitor at these points are time/temperature, factory, personal hygiene, and filleting practices. The procedure outlined for temperature below can be used to supplement the guidelines in Appendix 2 for hygiene and sanitation.

5.3.10 Monitoring of CPs in the production processes:

- a) Temperature control:
Time and temperature (T_{xt}) conditions at all times (all steps) from purchasing to dispatch is a CP in preventing growth of pathogenic bacteria.
 1. Time/temperature conditions during handling and processing can be done by date/time marking of containers, visual inspection of icing, chilling conditions and by taking temperature measurements.
 2. Time and temperature recording at specific points and during processing should be controlled by recording manually/automatically.
 3. Process flow must avoid stops and interruption, and all chill rooms must be supplied with thermometers.
 4. Visual inspection (e.g. quantity of ice) and control checks of temperature must be done as a daily routine.

A log on temperature recordings (manually or automatically read) must be kept and be available at all times. Examples of a temperature log are in appendix 9.

- b) Factory hygiene and sanitation:
Adherences to GMP as well as sanitation and factory hygiene procedures are CPs to reduce or avoid contamination and these control measures must be monitored as a daily routine (Appendix 2).
- c) Filleting practice: Newly recruited staff should be trained and put under observation.
- d) Packaging materials; The requirements for this are specified in the GMP.

5.3.11 Corrective Actions.

Column six on the HACCP plan form is used to establish corrective actions to be taken when monitoring indicates that there is a deviation from an established critical limit. Corrective action plans must be in place to:

1. Determine the disposition of a non-compliant product
2. Fix or correct the cause of a non compliant product to assure that the CCP is under control
3. Maintain records of the corrective actions that have been taken where there has been a deviation from critical limits
4. Assure that no product that is injurious to health or otherwise adulterated as a result of the deviation enters the market.

For the model plan, since the tolerance limit for pesticide is put at zero, and the procedure is the verification of the documentation and sample for pesticide residue. All fish supplied should have valid documentation. If not, the corrective action is to reject the supply. The purchasing officer is the responsible person.

For the laboratory results monitoring, if result is positive for pesticide residues, verify with the guidelines of the intended market. The corrective action is to withhold the consignment, look for alternative markets, or incinerate. The top management should take this action.

Because of the variations of CCPs for different processes and the diversity of possible deviations, specific corrective actions must be developed for each CCP. The actions must demonstrate that the CCP has been brought under control. The individual responsible for taking the corrective actions must sign documentation of the corrective actions.

5.3.12 HACCP records.

Column seven on the HACCP plan form is used to establish effective record keeping procedures that documents the HACCP system. The maintenance of proper records is an essential part of the HACCP system:

- a) To document that each CCP is under control
- b) To verify the adequacy of the HACCP plan

Records serve as:

- 1) Written documentation of the establishments compliance with their HACCP plan
- 2) The only reference available to trace the history of fish/raw material, in process operation or finished product, should problems arise;
- 3) A ready source of information to identify trends in a particular operation that may result in a deviation if not properly corrected
- 4) Good evidence in potential legal actions against the establishment

In accordance with the HACCP principles, HACCP records must include:

- Records associated with establishing critical limits

- Records for handling of deviations
- Records associated with verification of the HACCP plan.

It is also very important that all HACCP records dealing with plants operations at CCPs and corrective actions taken be reviewed on a daily basis by a designated individual who must sign, date and record the time when all records are reviewed. The approved HACCP plan and associated records must be on file at the fish-processing establishment.

The records to be kept for this model HACCP plan include document verification records and laboratory analysis records.

5.3.13 Review the HACCP plan.

Column eight of the HACCP plan establishes procedures for verification that the HACCP system is working correctly. The verification process is designed to:

1. Determine process control at each particular CCP. To establish whether the CCPs and critical limits have been properly established and are being adequately controlled and monitored.
2. To determine if the procedures for handling process deviations and record keeping practices are being followed.

The effective completion of this step is crucial since here is where you will define your critical limits that will be used to define CCP in your process.

5.4 Persons responsible for implementing HACCP

In a fish factory, this group consists of the quality assurance manager, the supervisor and the line operatives. It is essential that these persons receive the appropriate training for the success of the HACCP system will depend upon their understanding of what is required of them, and why it is required. The relevant areas of the HACCP study essential to the groups (Anon. 1994) are:

a) Quality assurance manager.

The training emphasis of this person should comprise of:

1. A full knowledge of the principles and the practical application of HACCP
2. Detailed explanation of hazards, critical control points, and monitoring and corrective actions
3. The quality assurance manager should constitute part of the HACCP team and be responsible for the overall management of the HACCP implementations.

b) The line operatives and supervisors.

These are the individuals responsible for controlling the manufacturing process and, as such, are the persons who actually implement the HACCP on the factory floor. Their role in assuring food safety is crucial and in order to fulfil their responsibilities they require training in the following:

1. The major sources of hazards in the product for which they are responsible and the effect of such hazards on product safety

2. The nature of control required at those points in the process for which they are responsible
3. The role of CCP in assuring product safety
4. The CCP monitoring procedures for which they are responsible and training in taking accurate and relevant readings/samples for monitoring purposes
5. Understanding of critical limits and target values identified by the study team for monitoring procedures
6. Corrective actions to be taken when a CCP moves outside a target value and/or critical limit
7. Correct record keeping procedures

The above training can be achieved partly by formal discussion, and practical example on the process line

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APPENDIX 1: GUIDELINES TO REGULATORY REQUIREMENTS ON GMP.

This appendix provides guidance to fish plant management to evaluate their existing prerequisite programs or to develop new programs. It outlines the minimum criteria that are to be met in each of the prerequisite program areas.

Areas covered under the prerequisite programs in the Ugandan legislation include:

Approval of establishment and official landing sites; General conditions of establishment and equipment; Hygiene; Conditions of storage and transport; Packaging requirements.

1. Approval of establishment and official landing sites.
 - The management of an establishment shall, before constructing, reconstructing or adapting an establishment, submit to the commissioner, for his or her approval, a plan of the establishment and a list of activities to be carried out by the establishment.
 - The commissioner may approve a plan submitted which meets the requirements concerning layout, product flow and other matters as prescribed in these rules.
 - Where an establishment carries out other activities than those for which it is approved, the commissioner may review the approval and shall take such actions as he or she may deem necessary.
 - The Commissioner may approve official landing sites, which meet such conditions as may be prescribed in guidelines issued by the commissioner.
 - The Commissioner shall ensure regular monitoring and inspection of establishments and official landing sites approved under these Rules.

2. Quality and self-tests
 - The management of an establishment shall draw up and submit to the Commissioner; a quality management program based on Good Manufacturing Practices (GMP)
 - The Commissioner shall issue guidelines for the preparation of a quality management program.
 - The management of an establishment shall implement a quality assurance system based on the Hazard Analysis Critical Control Points Principles principles (HACCP):
 - Identify hazards, and critical points in the establishments on the basis of the manufacturing processes and intended use of the products;
 - Establish and implement the method for monitoring and checking the critical points referred to above.

- Take samples for analysis in an officially approved laboratory for checking cleaning and disinfecting methods and for checking compliance with relevant national standards
- Keep a written record or records registered in an indelible manner, of the matters required by this rule with a view to submitting them to the Commissioner as proof that the system is operating within the set standard limits and the results of the different checks and tests, in particular, shall be kept for a period of at least two years.
- The management of an establishment shall submit to the Commissioner a copy of the HACCP plan prepared.
- The management shall carry out tests to ascertain the quality of fish and fish products handled by the establishment in accordance with the relevant national standards.
- If the results of the checks, or any other information at the disposal of the management of an establishment, reveal a health risk or suggest that a health risk might exist in the establishment, the management shall take such measures as may be appropriate and shall notify a Fish Inspector, who shall take appropriate action.

3. General conditions of establishment and equipment.

Every establishment shall have:

- A working area of sufficient size for work to be carried out under adequate sanitary and hygienic conditions; and
- A design and layout that preclude contamination of the product and keep the clean and contaminated parts of the building separate.

Areas where fish and fish products are handled, prepared or processed shall have:

- Waterproof flooring which is easy to clean and disinfect, and laid down in such a way as to facilitate the drainage of the water or provided with the equipment to remove water
- Walls with smooth surfaces which are easy to clean and disinfect, durable, and impermeable
- Adequate ventilation and where necessary, steam and water vapour extraction facilities
- Adequate natural or artificial lighting
- A ceiling of such height and of smooth washable surface that would ensure cleanliness
- An adequate number of facilities for cleaning, disinfecting hands in workrooms and lavatories provided with single use hand paper towels
- Taps shall not be hand operated
- Properly gazzetted and demarcated adequate, appropriate, well equipped facilities for cleaning and storage of equipment
- Doors of durable material which are easy to clean and resistant to corrosion
- Adequate vermin proofing and appropriate facilities for protection against vermin
- Instruments and working equipment such as cutting tables, containers, conveyor belts and knives that are made of corrosive resistant materials and are easy to clean and disinfect

- Facilities to provide adequate supplies of drinking water in accordance with Uganda standard US201: 1994 (Standard Specification for Drinking Potable Water) for the entire establishment
- Adequate trained and experienced supervisory staff
- In the cold room, chill room, ice room and raw material store where fish and fish products and ice are stored, the requirements in section 3 shall apply and where necessary, a sufficiently powerful refrigeration plant to keep products at the following temperatures:
 - Frozen fish products, with the exception of frozen fish in brine intended for manufacture of canned foods, must be kept at an even temperature of -18°C or less in all parts of the product, allowing for the possibility of brief upward fluctuations of not more than 3°C
 - Fresh products shall be kept at an even temperature of melting ice (0°C) allowing for the possibility of brief upward and downward fluctuation of not more than 2°C
- Adequate room for hygienic handling and storage of by products, in accordance with section 3 and the by-products shall be kept in acceptable non-corrosive containers
- A hygienic wastewater disposal system approved by the National Environmental Management Authority (NEMA)
- An adequate number of shower rooms, changing rooms and toilets with smooth, waterproof, washable walls and floors, wash basins and flush lavatories; they shall have adequate light and be well ventilated and the toilets shall not open directly onto the processing hall
- Wash basins shall have materials for cleaning hands and disposable paper towels
- A designated and adequately equipped facility for cleaning and disinfecting means of transport
- An adequately equipped lockable room for the Fish Inspector

Hygiene

An establishment shall maintain the following hygienic conditions:

- Floors, walls, and partitions, ceilings or roof linings, equipment and instructions used for working on fish and fish products shall be kept in a satisfactory state of cleanliness and repair so that they do not constitute a source of contamination for the fish or fish product
- Vermin shall be systematically exterminated in the premises or on the equipment; rodenticides, insecticides, disinfectants, and any other potentially toxic substances shall be stored in premises or cupboards which can be locked and their use shall not present any risk of contamination of the products
- Appropriate facilities for protection against vermin such as insects, rodents and birds shall be provided
- Working areas, instruments, and working equipment shall be used only for work on fish and fish products, unless the Commissioner has authorised that they be used at the same time or other times for work on other foodstuffs;
- Detergents, disinfectants and similar substances shall be approved by the Uganda National Bureau of Standards and used in such a way that they do not have adverse effects on the machinery, equipment and products

Maintain the highest possible standard of cleanliness of staff and ensure that:

- Staff wears suitable clean clothes and headgear, which completely encloses the hair
- Staff assigned to the handling or preparation of fish products washes their hands each time work is resumed
- Smoking, spitting, eating and drinking in work and storage premise of fish and fish products is prohibited
- Adequate amenities for hygiene and recreation including hand-washing facilities, toilets, changing rooms, and canteen are provided

Ensure that a medical examination is carried out

- Before the employment of any person by the establishment
- At least once every six months for every employee who comes into direct contact with, or otherwise handles or supervises the handling of fish or fish products

A medical examination shall be carried out with particular attention to:

- Infected wounds and sores
- Enteric infections, including parasitic diseases and carrier states, specifically Salmonella
- Respiratory diseases

Take all necessary measures to prevent any person whom:

- Is known to be suffering from communicable disease
- Has an infected wound or open lesion on any part of his or her body, from working on or handling fish or fish products, unless there is evidence that that person can do so without risk

Ensure that employees who handle fish do not wear fingernail polish, watches, rings, or other jewellery

1. Condition for storage and transport

- Fish and fish products shall, during storage and transport, be kept at the temperature specified in this schedule
 - Frozen fish products, with the exception of frozen fish in brine intended for manufacture of canned foods, must be kept at an even temperature of -18°C or less in all parts of the product, allowing for the possibility of brief upward fluctuations of not more than 3°C and
 - Fresh products shall be kept at an even temperature of melting ice (0°C) allowing for the possibility of brief upward and downward fluctuation of not more than 2°C
- Means of transport used for transporting fish or fish products shall not be used for transporting other products or objects likely to impair or contaminate the fish or fish products
- Vehicles used for the transportation of fish and fish products shall be constructed and equipped in such a way that the temperatures prescribed above are maintained throughout the period of transportation

- Where ice is used to chill fish or fish products, adequate drainage must be provided in order to ensure that water from melted ice does not stay in contact with fish or fish products
- It is an offence to transport fish products in a vehicle or container which is not clean or which is not disinfected or which does not meet the conditions laid down in the Rules
- Unloading and landing facilities shall be made and constructed of material which is easy to clean and disinfect and must be kept in a state of good repair and cleanliness

During unloading and loading the following conditions shall be adhered to:

- Unloading and loading operations shall proceed quickly
- Fish or fish products shall be placed without necessary delay in a protected environment at the temperature required based on the nature of the product
- Equipment and handling practices that cause unnecessary damage to the edible parts of the fish or fish products shall be avoided
- All vehicles used for transportation of fish and fish products shall be in a good state of repair to ensure fast and safe delivery
- Vessels used for fishing or transportation of fish or fish products shall be of adequate size and shall have sections of containers designed specifically for storage of fish or fish products to avoid contamination and to ensure temperature of melting ice (0°C)
- Vessels used for fishing or transportation of fish products shall regularly be painted with food grade paint to ensure easy cleaning and disinfecting
- No objects or products likely to transmit harmful properties or characteristics to fish or fish products shall be transported with the fish or fish products

General requirements for distribution of and monitoring of water

The management of an establishment shall:

- Account for the source of water supply whether mains, mains with intermediate storage, surface water or bore hole/well water
- Ensure that water used in the establishment is potable
- Be able to demonstrate the water distribution system within the establishment
- Provide a water reticulation plan within the establishment and consecutive numbering shall identify the outlets so that they can be located in the plan

Chlorinating system

The chlorinating system shall comply with the following:

- Chlorine shall be added in line by dosing or injection (gas or liquid) prior to intermediate storage to permit sufficient contact time with the water in order to allow chlorine to react with the organic matter
- The retention tank shall have the capacity to retain water together with chlorine added for 30 minutes
- The cleaning program for the intermediate tank shall be documented, monitored and demonstrated
- The residual chlorine for all water used for processing fish shall be in accordance with the water distributed by the National Water and Sewerage Corporation or other relevant authority

- The management of an establishment shall put in place measures to ensure the functioning of the chlorinating system, and the free residual chlorine shall be checked at least every two hours; and the chemical and microbiological quality of the water shall be in accordance with Uganda National Standard US201: 1994 (Standard Specification for drinking Water)
2. Conditions for packaging
- Packaging of fish and fish products shall be carried out under satisfactory conditions of sanitation and hygiene to preclude contamination
 - Packaging materials and products likely to come in contact with fish or fish products shall comply with the general rules of hygiene including the following
 - They shall not be such as to impair the organoleptic characteristics of the fish or fish products
 - They shall not be capable of transmitting to the fish or fish product, substances harmful to human health
 - They shall be strong enough to protect fish products adequately
 - Packaged products shall be labelled so as to accurately describe the container without misleading the consumer and shall be in accordance with Uganda National Standard US7: 1993 (Standard Specification for Labelling of Pre-Packaged Foods)
 - Packaging materials shall not be re- used except for containers made of impervious, smooth, and corrosion resistant materials, which are easy to clean and disinfect, and which may be re-used after cleaning and disinfecting
 - Packaging materials used for fresh products held under ice should provide adequate drainage for melt water
 - Unused packaging materials shall be stored in premises away from the production area and shall be protected from vermin, pests, dust, and contamination

APPENDIX 2: MONITORING AND CONTROL OF SANITATION

Eight essential areas of a sanitation program are identified for monitoring. These areas are most likely to have an impact on the safety of fisheries products. These areas are:

1. Water supply
2. Condition and cleanliness of food contact surfaces
3. Prevention from contamination
4. Employee practices
5. Hand washing and sanitising
6. Toilet facilities
7. Employee health conditions
8. Pest control

Monitoring and correcting non-compliance to sanitation can be done in two ways:

- a) Observe and record the conditions in the plant
- b) Make and record corrections for any deficiencies noted

There are many ways to set up a sanitation-monitoring program; one way is to place the sanitation elements into groups based on the frequency of monitoring. For example, decide which elements can be monitored monthly and daily. Then, prepare

the monitoring records accordingly. If monitoring were split into daily and monthly, then it would appear as:

A. Monthly monitoring

Three areas that can be covered in a monthly monitoring report are for example safety of water; condition and cleanliness of food contact surfaces; and prevention of cross contamination.

The conditions that are observed during monitoring can be reported as "Satisfactory/unsatisfactory", or "pass/fail".

a) Safety of water

How the water supply is monitored depends on the source of your water.

Municipal source:

Frequency: Having a copy of the water bill attached to the monthly report would usually be sufficient. Verification of the water quality from the municipal supply can also be requested and maintained on file.

b) Private source:

Frequency: Have the water tested for total coliforms as required by regulation. The results of analysis should be maintained with the monthly report.

c) Cross connections

Monitoring of plumbing cross-connections between potable water lines, non-potable water, and sewer lines.

Frequency: Once a month and more often if there are any changes to the plumbing.

d) Condition and cleanliness of food contact surfaces

Monitoring the condition of processing equipment and utensils to assure compliance and determine if it is necessary to replace inadequate equipment

Frequency: Once a month and more often if equipment is replaced or repaired to make sure that it meets the construction standards.

e) Prevention of cross contamination

The monitoring requirement for proper plant design can be as simple as a monthly walk-through of your facility to assure that the plant layout and structure does not contribute to contamination of the product. Examples of the kinds of conditions that could contribute to contamination are:

a) By-product line near finished product line,

b) Excessively crowded processing conditions.

Frequency: Monthly. If any modifications are made to the facility, additional monitoring would need to be done to assure that the change did not contribute to the possibility of contamination.

Note: All observations must be reported at the time the observation is made.

Correction is critical to the success of the monthly monitoring. Corrections that have been taken because of an observed deficiency are recorded.

For example, if you receive a report of analysis for well water that shows high total coliform counts, your correction may be to stop processing and to resample immediately. If the resample is satisfactory, processing can begin. Another acceptable corrective action would be to find an alternative water source until the problem is corrected. All of this information is to be recorded.

Record identification. The monthly report must include firm name, location, date of record and signature or initials of the person performing the monitoring.

A. Daily monitoring

The areas that can be covered in a daily monitoring report are parts of safety of water and condition and cleanliness of food contact surfaces and observed deficiencies.

a) Safety of water

In addition to concerns about cross connections between potable water lines, non potable water and sewer lines, there is the possibility of other cross connections in the plant environment, such as: unprotected hose bibs with the hose submerged in the wash tank; or cleaning chemicals metering pumps.

Frequency: At least once during the course of the day. If all water lines, including all hose bib, are protected with back flow prevention devices, daily monitoring may not be necessary.

b) Condition and cleanliness of food contact surfaces

The portions of this area that should be monitored daily are: cleaning and sanitising of equipment, utensils, gloves and outer garments that come in contact with food; and the condition of gloves and outer garments.

Frequency: Cleaning and sanitising of all equipment should be monitored every time the equipment is cleaned and sanitised. That should include monitoring of sanitiser strength. The actual strength should be reported. The condition and cleanliness of gloves and outer garments should be monitored at the start of the day's operations.

c) Prevention of cross contamination

The issues in the area of cross contamination that should be monitored are:

- Employee practices and physical separation of raw material/finished products
- Maintenance of hand-washing, hand-sanitising, and toilet facilities
- Protection from adulterants
- Proper labelling, storage and use of toxic compounds
- Employee health conditions
- Exclusion of pests

Note: just like the monthly monitoring records, daily monitoring records must reflect the actual conditions observed in the plant, as well as any corrections.

a) Employee practices

Frequency: Employee practices should be monitored at the beginning of the day's operation and at least every four hours during production, more often if necessary to ensure that employee's hands, gloves, equipment, and utensils are washed and sanitised, as necessary, after contamination. Monitoring employees that move from working in the raw material/by-product side of the operation to the finished product side should be done at least every 4 hours.

b) Hand-washing, hand-sanitising, and toilet facilities

Maintenance of hand washing, hand sanitising, and toilet facilities is essential.

- Hand-washing, hand-sanitising facilities

Frequency: The monitoring of hand-washing stations and the concentration of hand sanitising solutions should be done during the pre-op inspection

- Toilet facilities
- Frequency: The other part of this area is assurance that toilet facilities are adequate and in good repair. Seals around the bottom of each toilet, the functioning of the toilet and toilet supplies should be monitored at least before the start of the day's operations.

c) Protection from adulterants/labelling, storage and use of toxic compounds
Protection from adulterants and labelling, storage, and use of toxic compounds can be combined in monitoring and reporting.

- Protection from adulterants:
Frequency: Monitoring must be done to ensure that the food is protected from contaminants such as condensations, floor splash, glass and toxic chemicals. These conditions should be monitored at start-up and every four hours thereafter.
- Labelling and storage of toxic compounds:
Frequency: daily during the pre-op inspection.

a) Employee health conditions
Employee health conditions must be monitored daily.
Frequency: Daily, before the start of production.

b) Pest control:
Frequency: At a minimum, monitoring for pest should be done daily, during the pre-op inspection.

Corrections

As with the monthly report, critical to the success of the daily report are the corrections. The observed deficiencies are recorded.

For example, if a check of the storage warehouse found rodent excreta pellets, the correction might be to remove the pellets and clean the area before start-up, and to call the pest control company to report the observation.

Record identification

The daily report must include firm name, location, date of records and signature or initials of the person performing the monitoring.

APPENDIX 3: A REVIEW OF LITERATURE OF SEAFOOD HAZARDS OF IMPORTANCE TO THE NILE PERCH FISHERY AND FISH PROCESSING.

The International Commission on Microbiological Specification has defined hazards for Foods (ICMSF 1988) "As the unacceptable contamination, growth or survival of bacteria in food that may affect food safety or quality (spoilage) or the unacceptable production or persistence in foods of substances such as toxins, enzymes or products of microbiological metabolism".

The United States (US) National Advisory Committee on Microbiological Criteria for Foods (NACMF 1998) have defined a hazard as: a biological, chemical, or physical property that may cause a food to be unsafe for consumption

The definition according to NACMCF, which has grouped hazards into biological, chemical or physical property, will be used as a basis for this overview of the seafood hazards of importance to the Nile perch fishery and processing.

a) Biological hazards.

Seafood, like any other food has the potential to cause disease from bacterial, viral and parasitic pathogens. These agents can be acquired from sources like, faecal pollution of the aquatic environment, natural aquatic environment, and industrial, retail, restaurant, or home processing and preparation (Ahmed 1991).

Other biological hazards like biotoxins are accumulated by fish from the harvest areas through feeding on toxic algae or fish that have fed on the algae or toxin are naturally present in some species of fish e.g. tuna, mackerel.

Pathogenic bacteria of importance to seafood have been grouped into indigenous and non- indigenous pathogenic bacteria (Huss 1994).

b) Indigenous pathogenic bacteria.

They are common and widely distributed bacteria in aquatic environments, and water temperatures affects the distribution such that the psychrotrophic organisms (*Clostridium botulinum*, *Listeria* spp) are common in the colder climates, while the mesophiles (*V. cholera*, *V. parahaemolyticus*) are mainly found in the tropical zones. Bacteria belonging to this group include *C. botulinum*, *Vibrio* spp, *Aeromonas* spp, *Plesiomonas* spp, and *Listeria* spp.

Most of the indigenous pathogenic bacteria, which are psychrotrophs and not expected to form part of the natural flora on the Nile perch, a tropical warm water fish are not included in this overview. This includes the *C. botulinum*, *Aeromonas hydrophila*, *Plesiomonas shigelloides*, and the *Listeria monocytogenes*. Only the *Vibrio* spp in this group, which are of importance to the Nile perch and its products, are reviewed.

Vibrio species.

Most *Vibrio* spp are of marine origin and they require NaCl for growth. The species pathogenic to man are *V. cholera*, and *V. parahaemolyticus*. Other species including *V. vulnificus*, *V. holissae*, *V. furnsii*, *V. fluvalis* are not associated with any disease in man.

i. *Vibrio cholera*

Ahmed (1991) classified *V. Cholera* into O groups. Strains in O I group (*V. cholerae* I) causes cholera. Strains in other O group (non-, OI) are generally associated with milder illness.

The pathogenic species are mostly mesophillic, occurring in the intestines of humans, tropical and temperate waters.

Vibrios spp are reported to be capable of responding to adverse conditions (salinity, temperature, and nutrients) by entering a viable but non-culturable phase as reviewed (Huss 1994). This renders them undetectable by standard bacteriological methods and sample tests results will always be negative even if the virulent bacteria are present.

Disease symptoms:

The disease is characterised by watery stool, vomiting, prostration, dehydration, muscular cramps, and occasionally death. Incubation period ranges from 1 to 5 days.

Vibrio cholera were originally believed to be transmitted through faecal contamination of food and water, a mode of transmission that was said to be prevalent in the developing countries (Ahmed 1991). However, studies reviewed (Huss 1994) has now shown that free living strains of *V. cholera* O1 may be transmitted to man through consumption of raw, undercooked or cross contaminated shellfish. However, only a few cases (about 50) associated with this strain have been reported since 1973 (Ahmed 1991).

Epidemiology and risk assessment.

Cholera was referred to as the disease of the poor and the undernourished and mainly spread through water because of faecal contamination (Huss 1994). This indicates that, poor hygiene and sanitation is a major cause. Foods like soft drinks, fruits and vegetables and milk, have been implicated including raw, uncooked or cross-contaminated shellfish are the major vehicle food for *V. cholerae* O1 and non- O1 as reviewed (Huss 1994).

Vibrio has remarkable growth rate in raw fish, even at reduce temperatures. This allows a relatively low number to increase dramatically under improper conditions of harvesting, processing, distribution, and storage.

Disease control.

Inadequate sanitation and lack of safe water are reported to be major cause of cholera epidemics. Ensuring proper faecal disposal and safe drinking water (Huss 1994) can prevent this.

Normal cooking temperature is sufficient to eliminate vibrios as reviewed (Huss 1994). However, studies conducted by the Centre for Disease Control (CDC 1989) of the United States indicated that vibrio O1 is resistant to boiling for up to 8 minutes, and steaming for up to 25 minutes, in naturally contaminated crabs, requiring guidelines on time-temperature relations effective in the traditional pasteurisation methods of crabs.

Generation times as short as 8 to 9 minutes have been observed under optimal conditions (37°C) and reduced growth at lower temperatures indicating that proper refrigeration can be essential in controlling growth in vibrio though reported to be unreliable for commercial application (Huss 1994).

Table 3. Give survival time for *V. cholerae* in different food products at different temperatures (Huss 1994).

Food	Survival times(days)
Fish stored at 3-8°C	14-25
Ice stored at -20°C	8
Shrimp, frozen	180
Vegetables in a moist chamber, 20°C	10
Carrots	10
Cauliflower	20
River water	210

Vibrio parahaemolyticus

This is a mildly halophilic *Vibrio* commonly isolated from fish, shellfish, other marine sources, and inshore water and most abundant when water temperature exceeds 15°C. It is reported that the ability to cause human gastro-enteritis is most highly correlated with the production of a heat stable hemolysin as reviewed (Huss 1994).

Most strains isolated from the marine environment lack this hemolysin and are believed not to be pathogenic. However, several authors reported incidences of illness associated with the non-haemolytic strains along the US Pacific Coast. (Huss 1994)

V. parahaemolyticus reproduces rapidly at temperatures greater than 20°C and reach potentially infective levels of 10⁵ CFU/g in shrimps and crabs within 2 to 3 hours as reviewed (Huss 1994). It is heat sensitive and rapidly killed at 60°C.

Environmental strains that are probably non-pathogenic have been reported. They probably lack the necessary colonisation factors for adherence and penetration,

appropriate toxins or other virulence determinants necessary to cause pathogenicity (Huss 1994)

Epidemiology and risk assessment.

Reported cases of food borne diseases in Japan (CDC 1989), associated *V. parahaemolyticus* to crustacean shellfish, crabs, oysters, shrimps, and lobster as the major vehicle foods.

a) Non-indigenous bacteria.

These groups of pathogenic bacteria are important safety concerns in seafood during processing, distribution, and preparation. They mainly result from cross-contamination from equipment and personnel due to poor hygiene practices. Included in this group are *Salmonella*, *Shigella*, *E. coli*, and *S aureus*.

I. *Salmonella* spp.

Salmonella spp are members of the family Enterobacteriaceae and there are more than 2000 serovars. They are mesophilic, distributed geographically all over the world. Their common habitat is the gut of man, animals and environments polluted with human or animal excreta. Biological (interaction with other bacteria) and physical factors (temperature) are important parameters in its survival in water. Studies have shown that *Salmonella* and *E.coli* are capable of surviving and multiplying in the estuarine environment, tropical fresh waters for weeks (Huss 1994).

Disease characteristics.

Symptoms of salmonellosis (non-typhoid infections) are non-bloody diarrhoea, abdominal pain, fever, and nausea, vomiting which may appear 12 to 36 hours after ingestion.

Infective dose is as little as 20 cells (Huss 1994). Huss (1994) reported infective dose of greater than 10^6 cells.

Epidemiology and risk assessment.

Seafood appears to be a much less common vehicle for salmonella than other foods (Ahmed 1991). Most prawns and shrimps are cooked prior to consumption and therefore pose minimum risks to the consumer except by cross contamination in kitchens. This was borne out in an epidemiological study of seven outbreaks of seafood borne salmonellosis in USA in the period 1978 to 1987 (Ahmed 1991). Three of these outbreaks were due to contaminated shellfish including two outbreaks after consumption of raw oysters harvested from sewage- polluted water (Huss 1994).

II. *Shigella* species.

The genus *Shigella* also a member of the Enterobacteriaceae, consists of four distinct species. This genus is specific and adapted to humans and higher primates, and its presence in the environment is associated with faecal contamination. *Shigella* strains have been reported to survive for up to 6 months in water as cited in (Huss 1994).

Shigella spp is the cause of shigellosis, which is an infection of the gut. Symptoms vary from mild diarrhoea to dysentery characterised by bloody stools, mucus secretion, dehydration, high fever, and abdominal cramps. The incubation period is 1 to 7 days and symptoms may persist for 10 to 14 days. Deaths in adults are rare but common in children. In tropical countries with low standard of nutrition, shigellosis is reported to account for at least 500,000 deaths of children every year as reviewed (Huss 1994).

Epidemiology and risk assessment.

The great majority of cases of shigellosis are caused by direct person to person transmission of the bacteria via the oral faecal route. Water borne transmission is found to be important, especially where hygiene standard is low (Huss 1994).

Seafood, including shrimp cocktail and tuna salads has been implicated in a number of outbreaks of shigellosis. An infected carrier with poor personal hygiene has attributed most of the cases to contamination of raw or previously cooked foods during preparation.

III. Escherichia coli.

These are the most common bacteria in the intestinal tract of man and warm-blooded animals. Strains that colonise the intestinal tracts are harmless and are important in maintaining the intestinal physiology. Within the specie are at least 4 types of pathogenic strains (Huss, 1994).

1) enteropathogenic E. coli (EPEC), 2) enterotoxigenic E. coli (ETEC) 3) enterohaemorrhagic E. coli (EHEC) (verocytotoxin producing E. coli (VTEC) or E. coli O15: 47), 4) enteroinvasive E. coli (EIEC).

They are isolated in environments polluted with faecal materials or sewage, and are found to survive and multiply for a long time in the environment (Huss 1994). Recent studies demonstrated the existence of E. coli in unpolluted tropical waters, where it is found to survive indefinitely (Huss 1994).

Characteristics of illness.

The pathogenic E. coli strains produce the disease of the gut characterised by bloody diarrhoea, vomiting, cramping, dehydration and shock. It can also result in more serious symptoms depending on a number of factors e.g. pathogenic strains, susceptibility of the victim and degree of exposure (Huss 1994).

Epidemiology and risk assessment.

There is no indication that seafood is an important source of E. coli infection (Ahmed 1991). Most infections are related to contamination of water or handling of food under unhygienic conditions (Huss 1994).

Control of Enterobacteriaceae.

Enterobacteriaceae (Salmonella, Shigella, and E. coli) all occurs on fish products as result of contamination from the animal/human reservoir (Huss 1994). This contamination has been associated with faecal contamination or pollution of natural waters or water environments, where these organisms may survive for a long time or through contamination of products during processing.

Good personal hygiene and health education is therefore essential in the control of diseases caused by Enterobacteriaceae. Proper treatment (e.g. chlorinating) of water and sanitary disposal of sewage are also essential parts in the control program.

Risk of infection with Enterobacteriaceae can be minimised or eliminated by proper cooking of food before consumption. It is well established that the resistance of Salmonellae is low, but also that it varies considerably with available free water, water activity (a_w), and the nature of the solutes in the heating medium as reviewed (Huss 1994). A marked increase in heat resistance has been recorded at low a_w .

Generally, the growth is inhibited in the presence of 4.5% NaCl (Huss 1994)

Growth limiting factors for Shigella and some pathogenic E. coli are of no importance due to low infective dose required to produce disease (Huss 1994).

Current levels of salmonellosis in various foods and the increasing trends in human infections and food borne out breaks as reviewed (Huss 1994) underline that bacteriological testing and stringent bacteriological standards (zero tolerance limits) of most foods are insufficient measures in the control of samonellosis. Even the microbial quality of harvest water appears not to be a good predictor of salmonella contamination (Huss 1994) review.

IV. Staphylococcus aureus.

The Staphylococcus are ubiquitous organisms and can be found in water, air, dust, milk, sewage, floors, surfaces and all articles that come into contact with man, and survive well in that environment. The main reservoir and habitat is animal/human (Huss 1994), mainly in the nose, throat, and skin. The human carrier rate may be up to 60% of healthy individuals, with an average of 25 to 30% of the population being positive for enterotoxin producing strains (Ahmed 1991).

The disease caused by Staphylococcus is characterised by nausea, vomiting, diarrhoea, and abdominal cramps. Symptom may be severe and normal incubation time 3 to 8 hours and duration is usually 24 to 48 hours (Jay 1986).

Epidemiology and risk assessment.

Seafood may be contaminated with staphylococcus via infected food handlers or from the environment. More often, the contamination is from an individual with an infection on hands or with a cold or sore throat.

S. aureus is mesophilic with a minimum growth temperature of 10°C, but higher temperatures are required for toxin production (>15°C). It is halotolerant and able to grow at water activities a_w as low as 0.86 and minimum pH of 4.5. These requirements relate to the laboratory conditions when other factors are optimal. *S. aureus* is a poor competitor and the presence of staphylococcus in raw naturally contaminated food is of little significance. Rapid growth and toxin production can take place in pre-cooked seafood (shrimp) if re-contaminated with *S. aureus* and time temperature conditions is optimal. Enterotoxin produced during growth is resistant to proteolytic enzymes and heat. Normal canning procedure is capable of destroying the toxin but the heat applied in pasteurisation and normal household cooking is not sufficient to destroy the toxin (Huss 1994)

Disease control.

The knowledge of the underlying causes, poor personal hygiene and hygiene practices on the part of the food handlers or in adequate clean up or unsanitary equipment, and temperature control of the product are associated with staphylococcal poisoning (Bonnell 1994)

Good sanitary measures are necessary to prevent the contamination of seafood products with *S. aureus* because the enterotoxins are heat resistant and can withstand boiling temperatures for long periods of time (Huss 1994). The presence of *S. aureus* is almost unavoidable in products handled by humans. There are thus suggested guidelines for *S. aureus*. One hundred organisms per gram are the most common upper limit in these guidelines (Ahmed 1991).

Viruses.

Viral disease transmission to humans via consumption of seafood has been known since the 1950s (Huss 1994), and human enteric viruses appear to be the major cause of shellfish poisoning. Presently there are more than 100 known enteric viruses. However, only a few have been shown to cause seafood associated illness as reviewed (Huss 1994). These are. Hepatitis type A (HAV), Norwalk virus (small, round structured), Snow Mountain Agent, Calcivirus, Non-A, and Non-B.

Viruses are inert outside the living host cell, hence, do not replicate in water or seafood irrespective of time, temperature or other physical conditions. Their presence on seafood is purely a result of contamination either via infected food handlers or polluted water (Huss 1994).

Epidemiology and risk assessment.

The infective dose of virus is much smaller than that of bacteria for causing food borne disease (Cliver 1988). Bivalve molluscs dominate the lists of vehicle foods in outbreaks of viral diseases. However, another important vehicle involves ready-to-eat

food prepared by infected food handlers Almost any food that comes into contact with infected human hands and does not subsequently receive a substantial heat treatment, may transmit these viruses (Huss 1994).

With only few exceptions reported cases of seafood associated viral infections have been from the consumption of raw or improperly cooked molluscan shellfish as reviewed (Huss 1994). However, there is clear evidence that HAV has been transmitted by unsanitary practices during processing and distribution of food handling, and each year 20,000 to 30,000 cases are reported to the CDC in the US (Ahmed 1991). The largest outbreaks of food borne illnesses ever reported, is the outbreak of hepatitis involving 290,000 cases in China in 1988 (Huss 1994). This was linked to the consumption of contaminated and inadequately cooked clams as reviewed in (Huss 1994).

There are no documented cases of transmission of human enteric viruses other than Hepatitis A from seafood products contaminated at the processing, distribution, or handling level (Ahmed 1991).

All enteric viruses are resistant to pH, proteolytic enzymes, bile salts in the gut and to some common disinfectants e.g. phenolics, quaternary ammonium compounds, and ethanols. The halogens inactivate enteric viruses in water and clean surfaces. Hepatitis type A virus being one of the more heat stable viruses has an inactivation time of 10 minutes at 60°C (Eyles 1989) implying that, the virus is able to survive culinary preparations.

Disease control.

Prevention of food borne viral diseases relies on measures to prevent direct or indirect faecal contamination of food that will not receive a virucidal treatment before consumption.

Contamination by food handlers can be prevented by good personal hygiene and health education. Food handlers must not handle food while suffering from intestinal infections and for at least 46 hours after symptoms have disappeared. In cases of doubt, disposable gloves should be worn on critical operations, as viruses are difficult to remove from hands by washing and are resistant to skin disinfectants (Eyles 1989). Monitoring of harvesting areas has been based on bacterial indicators of pollution, a method now considered to be unreliable as an indicator of viral contamination as reviewed (Huss 1994).

Biotoxins.

Biotoxins are toxins produced by species of marine algae (phytoplankton). They accumulate in fish when they feed on the algae or on other fish that have fed on the algae. In addition, a few natural toxins are naturally occurring in certain species of fish e.g. tuna, mackerel etc.

Consumption of fish with these toxins can cause illness. Biotoxins most associated with seafood poisoning are; Tetrodotoxin, ciguatera and those associated with shellfish poisoning.

TABLE 4. Examples of Aquatic biotoxins. (Huss 1994).

Toxin	Where/when produced	Animal(s) organ involved
Tetrodotoxin	In fish ante mortem	Puffer fish (Tetraodontidae) Mostly ovaries, liver, intestines
Ciguatera	Marine algae	>400 tropical/ subtropical fish
PSP- paralytic shellfish poison	"	filter feeding shellfish, mostly
DSP- diarrhetic	"	digestive glands and gonads
NSP-neurotoxic	"	filter feeding shellfish
ASP-amnestic	"	" (blue mussels)

These toxins are highly regional and species related, and are already present in the fish or shellfish at harvest. The biotoxins are therefore of safety concern only in the species of seafood in which they are naturally present (Ahmed 1991).

The toxin and the disease they can produce have been described and reviewed (Huss 1994).

Control measures

There is no rapid check method, or commercial method for testing lots of fish for any of these toxins.

Natural toxins cannot be reliably eliminated by heat. However, severe heating processes, such as in retorting, may be effective in reducing the levels of some natural toxins (FDA 1998a).

A. Biogenic Amines. (Histamine poisoning).

Many commonly consumed fish, among them tuna and mackerel, are in the scombroid family. They naturally contain large amount of free histidine in their muscles. Bacteria such as *P. morganii*, which are common contaminants of fish tissue during spoilage, are capable of decarboxylating free histidine to form histamine.

Histamine poisoning, also called scombroid poisoning is a mild disease with very short incubation period (a few minutes) and short duration (Bonnell 1994).

The disease is characterised by facial flushing, oedema, and gastrointestinal tracts may be affected (nausea, vomiting, diarrhoea) as well as neurological involvement e.g. headache, tingling, burning sensation in the mouth (Huss 1994).

Epidemiological risk assessment.

Scombroid poisoning is reported to result from the consumption of fish with histamine levels above 200ppm, (FDA 1998a). The vehicle foods are the species of fish, which naturally contains the toxin in their muscles. This includes tuna, mackerel, mahi mahi and blue fish (Huss 1994).

There are also indications that decomposition can result in the production of other toxins (e.g., biogenic amines, such as putrescine and cadaverine) that have the potential to cause illness, even in the absence of histamine formation. Such illnesses have been reported for a number of fish species (FDA 1998b).

Control Measures

Low temperature storage and holding of fish at all times is the most effective preventive measure. All studies seem to agree that storage at 0°C or very near to 0°C limits histamine formation in fish to negligible levels.

B. Parasites.

Bonnell (1994) defined a parasite as an organism that lives in or upon another organism in order to derive nutrients. If well adapted, the parasite causes little or no harm to its host. The most important parasites of fish reported are the roundworms or nematodes. Species of nematodes of concern to the seafood industry, are the sealworm or the cod worm, *Phocanema decipiens* and *Anisakis simplex* or the herring worm.

Both of these can infect man, leading to the clinical conditions known anisakiasis. This is reported not to be a problem if fish is cooked to a core temperature of 60°C for one minute or where the fish is frozen to -20°C or lower for 24 to 48 hours. Raw or improperly cooked fish is reported to constitute a high risk (FDA 1997).

More than 50 species of helminth parasites from fish and shellfish are known to cause diseases in man. Most of these are rare and involve only slightly to moderate injury but some pose potential health risk. This includes; Cestodes or tapeworms

(*Diphyllobothrium latum*, *D. pacificum*); Trematodes or flukes. (*Clonorchis* spp., *Opisthorchis* spp, *Heterophyes* spp, *Echinostoma* spp, *Paragonimus* spp (Huss 1994). Epidemiology and risks assessment.

Parasites (in the larval stage) consumed in uncooked, or undercooked, unfrozen seafood can present a human health hazard. Among parasites, the nematodes or roundworms and trematodes or flukes are of most concern in seafood (FDA 1998e).

Control Measures

The process of heating raw fish sufficiently to kill bacterial pathogens is sufficient to kill parasites (WHO 1989)

Freezing to -20°C or below [internal or external] for 7 days or -35°C or below [internal] for 15 h also kills parasites.

Brining and pickling may reduce the parasite hazard in a fish, but they do not eliminate it, nor do they minimise it to an acceptable level. Nematode larvae have been shown to survive for 28 days brine (21% salt by weight).

Trimming away the belly flaps of fish or candling and physically removing parasites are effective methods for reducing the numbers of parasites. However, they cannot completely eliminate the hazard, nor do they minimise it to an acceptable level (FDA 1998e).

Whether or not parasites pose a health hazard to man is somewhat immaterial since their presence is unsightly and totally unacceptable to buyer of seafood products. Their removal represents a significant cost to the seafood industry, both in terms of labour and loss of yield. The Canadian seafood industry cites the cost of cod worm in the area of \$ 80 million annually (Bonnell 1994).

C. Chemicals:

Chemical contaminants with potential for toxicity in seafood and reported appears to be:

Environmental contaminants.

Inorganic chemicals: Antimony, Arsenic, Cadmium, Lead, Mercury, Selenium, and Sulphites.

Organic compounds: Polychlorinated biphenyl, dioxins, insecticides (Chlorinated hydrocarbons); and

Processing related compounds; Nitrosamines and contaminants related to aquaculture (Ahmed 1991).

Others reported as of safety concern in the seafood processing industries includes cleaning compounds and, plasticisers from packaging materials (Mortimore and Wallace 1994).

Other compounds of elements such as copper, selenium, iron, and zinc which are ubiquitous in the clean aquatic environment, and in modest concentrations, are essential nutrients of fish and shellfish. Contamination by these compounds only occurs when there is marked increased in their levels in the organisms.

Problems related to chemical contamination of the environment are man made. The dumping of waste materials from industrial processing, sludge from sewage treatment plants, chemicals used in agriculture and untreated waste all drains into the sea. These chemicals end up in fish and other aquatic organisms, where they build up in the food chain. (Huss 1994), reported that the presence of chemical contaminants in seafood is highly dependent on geographical location, species, size, feeding pattern, solubility of the chemicals and their presence in the harvest area.

Cleaning chemicals are among the most significant chemical hazards in seafood processing operations. They remain on utensils, equipment as cleaning residues, and

are transferred directly onto foods, or splashed on to food during the cleaning of adjacent items (Mortimore and Wallace 1994)

Available statistical report indicates chemicals as a cause of seafood poisoning to be rare. Reviews on chemical concerns in seafood concluded that risk from chemical contaminants in commercially harvested fish and shellfish is low and pose no significant problem as reviewed (Huss 1994).

Plasticisers and other plastic additives can be of concern if they are able to migrate in to food. Migration depends on the constituent present and on the type of food, e.g. fatty foods promote migration more than some other food tuffs.

Control measures.

For environmental contaminants:

Make sure that incoming fish have not been harvested from waters that are closed to the commercial harvest of that species due to environmental chemical contaminant or pesticides.

Screening the incoming fish to ensure that a licensed or certified dealer supplies them, Testing of fish flesh at the time of receipt for environmental chemical contaminant and pesticide residues.

Cleaning chemicals, plasticisers, and packaging migrations;

Use of non-toxic chemicals, where possible,

Design and management of appropriate cleaning procedure e.g. adequate training of staff, and may involve post cleaning equipment inspections.

Legislation controls the constituents of food contact plastic and packaging, along with the maximum permitted migration units in a number of food models.

D. Physical Hazards (Hard or Sharp Objects)

"Physical hazards are extraneous or foreign objects or any physical matter not normally found in food which may cause illness (including psychological trauma) or injury to an individual". (Bonnell 1994).

Foreign objects are broadly classified as, 1)-food safety hazards (e.g., glass) and, 2) food non-safety hazards (e.g., filth). Foreign objects that are physical hazards are referred to as hard or sharp objects and are divided into metallic objects and non-metallic objects.

Hard or sharp foreign objects in food may cause traumatic injury including laceration and perforation of tissues of the mouth, tongue, throat, stomach and intestine as well as damage to the teeth and gums. Foreign objects that are less than 7 mm, maximum dimension rarely cause trauma or serious injury except in special risk groups such as infants, surgery patients, and the elderly (Mortimore and Wallace 1994).

Hard or sharp natural components of a food, e.g. bones in seafood, are unlikely to cause injury because of awareness on the part of the consumer that the component is a natural and intrinsic component of a particular product. The exception occurs when the food's label indicates a boneless product e.g. fish fillets.

Metal fragments.

Metal-to-metal contact, especially in mechanical cutting or blending operations, other equipment with metal parts that can break loose, such as moving wire mesh belts, screens, portion control equipment and can openers are likely sources of metal that may enter food during processing.

Metal inclusion should be considered a significant hazard at any processing step. Like all hazards, the presence of hard or sharp objects must be critically evaluated for its significance as a potential health hazard. Factors that must be taken into consideration include, but are not limited to, historical processing data, lost or broken processing

equipment parts, and consumer complaints from both institutional and retail customers.

Not all metals equipment constitutes a significant potential metal inclusion hazard. Fillet skinner, metal mesh conveyor belts, and similar equipment rarely cause metal inclusion hazards (FDA 1998d).

Control measures includes: Periodically checking cutting, blending, portioning, or other equipment for damage or missing parts and passing the product through metal detection or separation equipment (FDA 1998d).

A. Risk assessment of seafood hazards in Nile perch processing and products.

Nile perch, *Lates niloticus* is a carnivorous tropical fresh water fish, which preys on its own juveniles and other smaller species. Fishermen of L. VICTORIA normally harvest Nile perch by gill netting. It is iced on board and transported to the beaches for auctioning.

Like any other seafood, Nile perch products (fresh and frozen fillets) are liable to contamination with the three types of food hazards, which may be derived from either the fishing ground, or through handling, processing, and distribution processes. Three types of hazards of safety concern in seafood reviewed are Biological, chemical and physical.

1) Biological hazards.

Includes: Pathogenic bacteria, parasites, viruses, and biotoxins.

a) Pathogenic bacteria;

Huss (1994) grouped pathogenic bacteria associated with seafood into indigenous and non-indigenous. The indigenous bacteria are either mesophiles or psychotrophs, and their distribution in the aquatic environment depends on water temperatures. The mesophiles are dominant in the tropical waters and includes species of *V. cholerae*, and *V. parahaemolyticus*, this is expected to be part of the natural flora on the Nile perch at harvest.

I. *Vibrio cholerae*.

The *Vibrio* spp that are pathogenic and important to seafood are transmitted through faecal contamination of water and food, a method of transmission that is associated to poor hygiene and sanitation (Huss 1994). *V. cholerae* can therefore be a potential hazard on Nile perch products if the Nile perch are harvested from fishing grounds contaminated with faecal material.

NARO (1997) indicated that the inshore waters of Lake Victoria are more likely to be contaminated with pathogens than off shore. Complying with regulatory requirements, that fish/raw material only is landed and marketed from gazetted beaches, having the essential sanitary facilities can reduce the risk of cross contamination and the hazard from this pathogen.

Handling and preparation of Nile perch products, as required by regulations is carried out at chilled conditions (< 4°C). Reports indicate that vibrio is capable of growing at reduced temperatures (Huss 1994). There is therefore a high chance of the bacteria reaching the infective dose during the handling and preparation of Nile perch products. However, the risk associated with products to be cooked is reported to be low, as the bacteria are eliminated at normal cooking temperatures. Though *V. cholerae* O1 resists boiling and steaming for up to 8 and 25 minute respectively as reviewed in (Huss 1994). This suggests that there could be a time/temperature guideline for control, not specified in the literature.

V. cholera is only a potential contaminant in seafood in situ, and can be destroyed by heat treatment, and recommended proper cooking at primary processing and

avoidance of recontamination of the cooked product as a control measure (Ahmed 1991).

It can thus be concluded that measures aimed at reducing the risk of the pathogen in Nile perch products should focus on the elimination or reduction of contamination of the raw material, eliminates it from the product and avoid re-contamination after cooking.

II. *Vibrio parahaemolyticus*.

This is a common marine isolate, mesophilic organism, but unlike *V. cholera*, it is not associated with faecal pollution (Ahmed 1991). Therefore, its potential as a safety concern in seafood and particularly Nile perch product is probably by virtue of it being part of a natural contaminant on the Nile perch fish at harvest.

It is reported that *V. parahaemolyticus* grows rapidly at 20°C, and reaches infective dose 10⁵ CFU/g in 2 to 3 hours. Nile perch production is at chilled conditions, as required by GMP and the estimated time for a fillet on the processing line is 30 minutes (Anon. 1998c). The chance of *V. parahaemolyticus* growing and reaching the infective dose is therefore minimal.

V. parahaemolyticus is killed at 60° C (Huss 1994). There is thus minimal risk in products to be cooked before consumption.

Control measures in Nile perch products may include avoiding time temperature abuse during processing, cooking the product before consumption and avoid recontamination of the cooked product. It can therefore mean that there is very minimal risk of vibrio infection Nile perch products, which are meant to be cooked

a) Non-indigenous pathogens.

Pathogenic bacteria belonging to group is in the family, Enterobacteraceae and includes. *Salmonella* spp, *Shigella* spp, *E. coli* and *S. aureus*.

I. *Salmonella*, *Shigella*, and *E. coli*.

They are mesophilic and associated with faecal pollution. Their occurrence on fish/ fish products is mainly because of cross contamination from equipment, personnel due to poor hygiene practices (Huss 1994).

NARO (1997) of Uganda established that the faecal or thermotolerant coliform counts and therefore incidences of *Salmonella* spp. were higher at the in-shore waters where the beaches are located than in the offshore waters, especially those beaches densely populated with inadequate sanitary facilities. Consequently, there is risk at this stage that fish during offloading, will become contaminated with pathogenic strains than at off shores.

To reduce this risk, under the fish quality assurance rules, only beaches with adequate sanitary facilities were gazetted for landing and marketing fish. The industrial processors are required to purchase fish only from the gazetted landings

The potential of contamination of Nile perch products with this group of pathogenic bacteria is high where personal hygiene practices and water quality is poor. A lot of handling is involved during preparations of Nile perch fillets, and in a situation of poor hygiene practices and sanitation cross-contamination is inevitable.

Most reported epidemiological studies on cases of *Salmonellae*, *Shigella* and *E. coli*, associated the occurrence of the diseases to eating raw or under cooked shellfish or from cross-contaminated cooked food or water contaminated with faecal matter (Ahmed 1991). Similarly, if raw, half-cooked or cooked and cross-contaminated Nile perch product is eaten; it can result in infections from the pathogens.

Minimal risk of infection is involved with products to be cooked, as proper cooking eliminates the bacteria. This reduces the risk involved with these pathogens in Nile

perch products, as they are to be cooked prior to consumption. Caution should however be taken to prevent cross contamination in to the cooked product. Salmonella resistance varies with the water activity, nature of solutes in the medium (Huss 1994). Growth is said to be inhibited at 4.5 % NaCl (Huss 1994). Implying, cooking may only be effective at certain minimum conditions.

The only sure method of control for absolute safety is to eliminate initial contamination in the raw material from the source. Training in personal hygiene, sanitation and assuring water quality can provide additional safety measures.

II. Staphylococcus aureus.

It is widely reported in literature that the main reservoir for this pathogen is man, with a carrier rate of up to 60% in healthy persons for the pathogenic strain (Ahmed 1991). The potential of occurrence of this pathogen in Nile perch products is mainly because of cross contamination from the personnel, equipment, and water. The production process of Nile perch fillets involves: filleting, skinning, and trimming all done manually. Cross contamination from the personnel to the product in this case is inevitable. Besides, contamination is also possible from equipment and water. *S. aureus* is reported to be a poor competitor (Huss 1994). Its potential as a hazard in the Nile perch product is therefore minimal. A typical Nile perch fillet is expected to be contaminated with bacteria derived from the harvest water, equipment, and personnel. These bacteria would check the growth of *S. aureus*, and therefore toxin production.

Huss (1994) the minimum temperature for growth of the bacteria is 10°C, and that for toxin production is 15°C, this is quite above the chilled conditions (4°C) at which Nile perch products are prepared as required by regulations. The chances of growth and production of toxin is therefore limited.

However, in case of cross contamination into the cooked product, *S. aureus* rapidly grows and produces the toxin, which is resistant to both proteolytic enzymes and heat, and cannot be destroyed by normal cooking and pasteurisation temperatures. The toxin if eaten in the food can result in food poisoning.

There is therefore very little risk involved with this pathogen in the Nile perch product.

From the underlying causes of staphylococcal poisoning, it is apparent that one of the best options to the control food poisoning from *S. aureus* is the training of personnel in good hygiene practices, clean up procedure, and production processes.

a) Viruses.

The presence of virus in seafood as reported is purely because of cross-contamination either via the infected food handler or polluted water (Huss 1994). The potential of viral contamination in Nile perch products is possible on these grounds

Most reported cases of viral diseases related to seafood are linked to bivalve molluscs and shellfish, because of the ability to concentrate the organism from water through filter feeding. Cross contamination due to unsanitary practices during distribution, processing, and handling is reported as important in transmitting viral diseases (Ahmed 1991)

The infective dose for viral infection is very low compared to that of bacteria. Even at very low concentrations, it is able to cause disease though, the risk in food to be cooked before consumption is minimal, as the virus is killed at cooking temperatures. Hepatitis A is reported to be more heat stable, has an inactivation temperature of 60°C (Eyles 1989), and may resist certain cooking methods e.g. steaming and frying. Strategies aimed at controlling diseases due to viral infections in Nile perch products should include prevention of contamination in products that is not to receive a

virucidal treatment before consumption and training of the food handlers in good hygiene practices.

b) Biotoxins.

These are biological hazards associated with seafood either because they are naturally present in them or are accumulated in them through the food chain. It is a species related hazard associated with shellfish and species of the scrombroid family e.g. tuna, mackerel etc. Nile perch has not been associated with any known toxins naturally or through the food chain.

There is possibly no risk of this type of hazard in the Nile perch products.

c) Parasites.

Reports available in literature indicates that nematodes are the most important parasite of fish, and the species of most concern to the seafood industry are the seal worm or cod worm and the herring worm (Bonnell 1994).

There are no documented study reports available on parasites on Nile perch, and therefore not possible to specifically associate it with any particular pathogenic parasite. The risk involved with this particular hazard in the products of Nile perch at moment is difficult to assess. Besides, association of a parasite and a host is specific; thus the question of cross contamination due to pollution and poor hygiene practices may not arise.

Reported cases of infection by seafood are mainly linked to those products that are consumed raw or under cooked or unfrozen, Parasites may therefore not be an important safety concern in the frozen Nile perch products, even if it may be present. Similarly, the risk involved in chilled products, is minimal, as all Nile perch products are supposed to be cooked before consumption.

1) Chemicals.

Chemical hazards in seafood are the result of either environmental contaminants in the harvest waters, processing related compounds, cleaning or migrations from packaging materials.

The risk involved with environmental contamination is related to geographical location, species, size, feeding pattern, and solubility of the chemicals and their presence in the harvest area. (Huss 1994). Currently, there is no status report available on the level of contamination of Lake Victoria with chemicals, although incidences of killing fish using pesticides has been reported in the press. As a control measure, the local government requiring the registration of all fishermen passed a by law. A documentation system is also in place making it possible to trace the fish (raw material) to the fisherman, and there is intensive water surveillance to reduce the malpractice. There is also community policing, initiated by the fishermen themselves. Fish processors, by the same law, are required to buy fish only from registered fishermen/suppliers with valid documentation.

It is therefore, still difficult to assess the risk involve with this hazard in the Nile perch product. The perceived hazard by the market is high and therefore it should be treated as such.

Measures used to control environmental contaminants by the fish companies in Uganda are the testing of Nile perch fillets periodically for chemical and pesticide residues

Nile perch products are prepared fillets, which are either chilled or frozen, and therefore, no chemicals are used as part of the ingredients. Hence, there are no hazards related to processing chemicals.

Cleaning chemicals and packaging materials used in the fish processing factories are by regulations required to meet some requirements. The potential of this group of chemicals as a safety concern is taken care of through GMP.

2) Physical hazards.

Physical hazards may include glass, metal fragments, metal parts, and any hard object that is above 7-mm dimension according to Guidelines (FDA 1997).

Glass materials are by regulation, not used in the fish processing, packaging areas. They are part of the Good Manufacturing Practices, thus may not be a potential hazard in the Nile perch product.

Fish processing companies in Uganda are not highly mechanised, physical hazards likely to result from metal fragments and metal inclusions from the processing equipment is therefore unlikely.

Mortimore and Wallace (1994) reported that equipment like fillet skimmers, metal mesh conveyors, and similar equipment used in the fish fillet plants might not be a serious source of hazard. This is only possible when there is good maintenance practices on the equipment.

Though some factories may have skinning machines, conveyors, these may not be significant metal hazards. It is therefore probable that, the production processes employed in the production of Nile perch fillets may not pose many risks related to physical hazards.

Conclusion.

Reviews of the epidemiological studies, risk assessment, of the "seafood hazards" in the Nile perch products, indicates, the pathogenic bacteria are the potential hazards of most concern in the Nile perch product. This may result from cross contamination, followed by time temperature abuse through the process chain. There is also possibility of cross contamination during preparations in the kitchen (home preparations).

At the factories, the handling and distribution conditions can increase or decrease the levels of contamination or growth of the pathogens; these can be controlled through GMP and by HACCP monitoring system.

The issue of killing fish using pesticides is still circumstantial. Because of the implication it has caused to the marketing of the Nile perch products, it is prudent for control to be exercised with respect to this hazard.

APPENDIX: 4: EXAMPLES OF QUESTIONS THAT CAN BE USED IN HAZARD ANALYSIS

The Hazard Analysis consists of asking a series of questions, which are appropriate to each step in a HACCP plan. The sample questions in the module are not exhaustive. There may be other questions pertinent to your process. The Hazard Analysis should question the effect of a variety of factors upon the safety of the product.

A. Raw material

Does the raw material present any risk from biological hazards (e.g., Salmonella, Staphylococcus aureus);

- Chemical hazards (e.g. pesticide residues)?
- Physical hazards (stones, glass, metal)?
- Is potable water in the handling process?

B. Intrinsic factors

Physical characteristics and composition (e.g., pH, water activity) of the food.

- Which intrinsic factors of the food must be controlled in order to assure safety?
- Does the food permit survival or multiplication of pathogen and/ or toxin production in the food during processing?
- Will the food permit survival or multiplication of pathogens and/or toxin formation during subsequent steps in the food chain?

C. Procedures for processing

- Does the process include a controllable processing step that destroys pathogens? Consider both vegetative cells and spores:
- Is the product subject to contamination between processing and packaging?

D. Facility design

- Does the layout of the facility provide an adequate separation of raw material from final product?
- Is positive air pressure maintained in the product packaging areas? Is this essential for product safety?
- Is the traffic pattern for people and moving equipment a significant source of contamination?

E. Equipment design

- Is the equipment properly sized for the volume of production and does it ensure the controls e.g. temperature that is necessary for the safety of the product?
- Can the equipment be sufficiently controlled so that the variation in performance will be within the tolerances required to produce a safe product?
- Is the equipment reliable or is it prone to frequent breakdown?
- Is the equipment designed so that it can be cleaned and sanitised?
- Is there a chance for product contamination with hazardous substances (e.g., glass)?
- What product safety devices are used to enhance consumer safety (e.g. metal detectors, thermometers)?

F. Packaging

- Does the method of packaging affect the multiplication of microbial pathogens and/or the formation of toxins?
- Is the package clearly labelled "keep frozen/refrigerated" if this is required?
- Does the packaging include instruction for the safe handling and preparation of the food by the consumer?
- Are tamper-evident packaging features used?
- Is the packaging material resistant to damage thereby preventing the entrance of microbial contamination?
- Is each package and case legibly and accurately coded?
- Does each package contain the proper label?

G. Sanitation

- Can sanitation impact upon the safety of the fish product that is being processed?
- Can the facility and equipment be cleaned and sanitised to permit the safe handling of the fish?

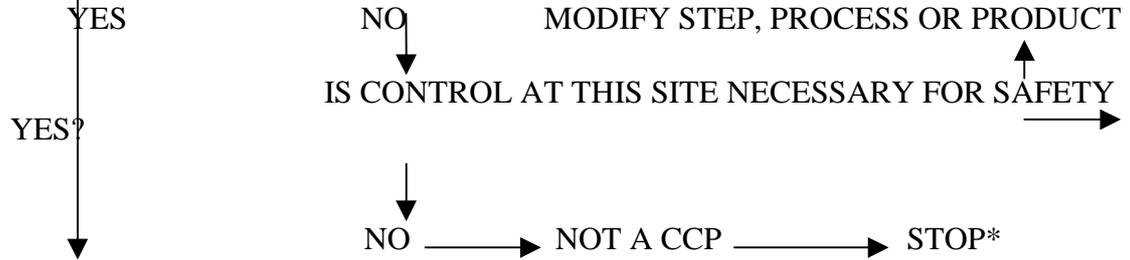
- Is it possible to provide sanitary conditions consistently and adequately to assure safe fish products?
- H. Employee health, hygiene, and education
- Can employee health or personnel hygiene practices impact on the safety of the fish product?
 - Do the employees understand the process and the factors they must control to assure the preparation of safe fish products?
 - Will the employees inform the management of a problem, which could impact upon safety of products?
- I. Conditions of storage between the packaging and the consumer:
- What is the likelihood that the product will be improperly stored at the wrong temperature?
 - Would an error in storage lead to a microbiologically unsafe product?
- J. Intended use
- Will the consumer cook the food?
 - Will there be likely leftovers?
- K. Intended consumer.
- Is the food intended for the public?
 - Is the food intended for consumption by a population with increased susceptibility to illness (e.g. infants, the aged, the infirm, immune-compromised individuals).

APPENDIX 5: CCP DECISION TREE

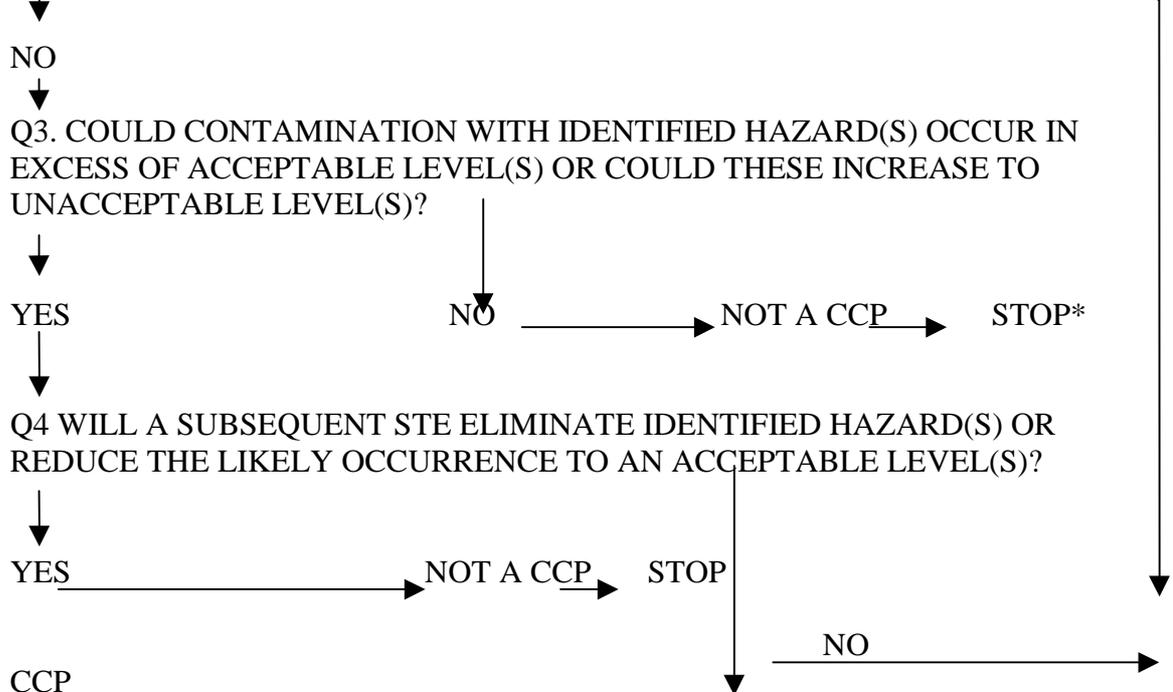
CCP DECISION TREE

(Apply at each step of the process with an identified hazard)

Q1 DO PREVENTIVE MEASURE (S) EXIST FOR THE IDENTIFIED HAZARD



Q2 DOES THIS STEP ELIMINATE OR REDUCE THE LIKELY OCCURRENCE OF A HAZARD TO AN ACCEPTABLE LEVEL?



CCP

* Proceed to the next step in the process

APPENDIX 6: CHECKLIST FOR HYGIENIC PRACTICES

TABLE 1: Hygienic practices checklist.

PLANT: _____ DATE: _____
 INSPECTOR: _____ SHIFT: _____

REQUIRED PRACTICE	S	N	U	COMMENTS
Employee health				
Employee appearance				
Finger polish				
Jewellery				
Smoking				
Spitting				
Gum chewing				
Hand washing/dipping				
Headgear				
Beards				
Outer garments				
Hand coverings				
Toilet areas				
Visitors				
Foot dips.				

S = Satisfactory; N = Needs improvement; U = Unsatisfactory.

Sampling frequency: 1/shift

COMMENTS/ACTION INITIATED:

APPENDIX: 7 TABLE FOR SANITATION CHECKLIST

TABLE: 3 Sanitation Checklist

DATE: _____ PLANT: _____ INSPECTOR: _____

AREA		S	U	COMMENTS
Grading room:	Tables			
	Walls			
	Floor			
Fish storage room	Walls			
	Floor			
	Storage bins			
Processing room: A: Filletting area B: Trimming area: C: Packing area:	Fish tubs			
	Cutting table frame			
	Cutting boards			
	Fillet pans			
	Table frame			
	Trimming boards			
	Candling tables			
	Fillet pans			
	Table frame			
	Weight scales			
	Fillet trays			
	Packing/holding area:			
Wash rooms	Men			
	Women			
Freezing section	Freezers			
	Walls and floors			
Cold storage	Temperature			
	Storage of product			
Dry storage:				
Pan washing area				
Dispatch area:				
Water supply	Bacteria			
	Chlorine residue			
Establishment surroundings				

