

NATIONAL AQUACULTURE BIOSECURITY GUIDELINES

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Acronyms

AMR: Antimicrobial Resistance

EU: European Union

FAO: Food and Agriculture Organisation of the United Nations

FDFA: Federal Department of Fisheries and Aquaculture

FMAFS: Federal Ministry of Agriculture and Food Security

HACCP: Hazards Analysis and Critical Control Points

IPC: Infection Prevention Control

NAAHS: National Aquatic Animal Health Strategy

RAS: Recirculating Aquaculture System

WOAH: World Organisation for Animal Health (formerly named OIE)

WASH: Water and Sanitation Hygiene

Glossary

Feed Additives are products used in fish nutrition for purposes of improving the quality of feeds and to improve the growth performance and health of fish. Examples of feed additives include amino acids (lysine and methionine), vitamins and mineral premixes, prebiotics, probiotics, enzymes, mycotoxin binders, yeasts, etc.

Aflatoxin is a toxin naturally occurring in moulds such as *Aspergillus flavus*

Antimicrobials are es (agents used to prevent and/or treat infectious diseases in humans, animals, plants, and include antibiotics, antivirals, antifungals, and antiparasitics (WHO - <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>)

Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and/or parasites no longer respond to antimicrobial (agents). As a result of drug resistance, antimicrobials become ineffective and infections become difficult or impossible to treat, increasing the risk of disease spread, severe illness, disability and death (WHO <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>)

Aquaculture involves the rearing of aquatic plants and animals such as algae, seaweeds, crustaceans, molluscs, amphibians, reptiles and finfish in enclosures or confined aquatic environments such as freshwater, brackish water or marine.

Biosecurity is the prevention of disease-causing agents from entering or leaving any place where they can pose a risk to farm animals, other animals, humans, and/or the safety and quality of a food product (Department of Agriculture, Environment and Rural Affairs - DAERA <https://www.daera-ni.gov.uk/articles/biosecurity>).

Broodstock refers to a cohort of mature fish, specifically selected and kept for breeding to yield offspring for aquaculture or replenishing natural water habitats. These individuals are selected based on particular traits of interest: growth rate, disease resistance, feed conversion efficiency, adaptation and other desirable traits to enhance the productivity and overall qualities of the offspring (FAO -2019a).

Contamination is the introduction of impurities, pollutants or harmful substances into a system or environment, leading to degradation of quality, purity or safety standards. In technical terms, contamination can refer to the presence of unwanted elements that can adversely affect the intended use or function of a material, product or system (ISO 14001:2015).

Disease is defined as a pathological condition of an organism that impairs its normal physiological functioning and manifests through specific symptoms. It involves a deviation from a healthy state due to factors such as infections, genetic disorders, environmental influences or other causes, affecting the structure or function of an organism (DIMD, 2012).

Equipment refers to tools, machinery or other items needed for a particular purpose or activity. It can include devices, instruments or apparatus used in various fields such as manufacturing, construction or research. (<https://www.merriam-webster.com/dictionary/equipment>)

Feedstuffs refer to the various ingredients or materials used in formulating animal feeds. These can include grains, protein sources, minerals, vitamins and additives that are combined

to create a balanced diet for livestock or poultry. (https://www.asas.org/about/national-association-governance/committees/publications/glossary-of--animal-science-terms/letter_f)

Fingerlings and Juveniles are young fish that have reached a stage where they have functional fins, and have reached the size of a human finger, hence, the name fingerlings. In Nigeria, the catfish fingerlings are about 4 - 6 cm, weighing 0.5 - 1.5 g, while juveniles are 8 cm and above in length, weighing 2.5 g and above (Isa, 2023). Tilapia fingerlings weigh a minimum of 1 g and have developed functional and visible fins and scales. They are typically at a size where they can be easily handled and transferred for stocking in aquaculture operations or natural water bodies. (<https://www.merriam-webster.com/dictionary/fingerling>)

Fish Farmers (Out-growers) are individuals or entities involved in the cultivation, rearing and harvesting of fish within the aquaculture value chain. They are sometimes called outgrower and under certain contractual agreements, out-growers raise fish to a specific size or developmental stage before returning them to the primary farm for additional growth or processing (FAO, 2019b).

Fish Feeds are specialised formulations of various ingredients used to provide essential nutrients to fish in aquaculture settings. These feeds are designed to meet the dietary requirements of different fish species at various life stages, promoting growth, health and overall performance.

Fish Processors are individuals or companies involved in the processing and preservation of fish products for distribution and sale. This can include activities such as filleting, smoking, freezing, canning or packaging of fish to make them suitable for consumption by consumers (FAO, 2011).

Hatchery is a facility where fish eggs are incubated and hatched, and the resulting larvae, fry or fingerlings are raised under controlled conditions before being transferred to grow-out facilities or released into natural water bodies (FAO, 2007).

Hazard Points are specific locations or stages within a process where hazards can be introduced or where control measures are necessary to prevent risks to food safety.

Inputs refer to the resources, materials or components used in a process or system to produce desired outputs. In the context of aquaculture, inputs can include feed ingredients, water, equipment, labour, and other essential elements necessary for fish farming operations (FAO, 2019b).

Pathogens are microorganisms such as bacteria, viruses, fungi or parasites that can cause disease in plants, animals or humans. They have the potential to infect and harm their host organisms, leading to illness or other adverse effects (Centre for Disease Control and Prevention, 2021).

Production System refers to the method or process used to produce goods or services efficiently and effectively. It includes the combination of resources, technologies and activities involved in the production process to achieve desired outputs (Heizer and Render, 2016).

Raw Materials are substances or components used in the manufacturing or production of goods. These materials are typically in their natural state or minimally processed form and are

transformed into finished products through various manufacturing processes. (<https://www.businessdictionary.com/definition/raw-materials.html>)

Risk Assessment is a systematic process of identifying, evaluating and prioritising potential risks or hazards in a given situation. It involves analysing the likelihood and consequences of these risks to determine the best course of action to manage or mitigate them effectively (<https://www.hse.gov.uk/risk/index.htm>).

Stocking Density refers to the number of organisms, such as fish, stocked in a given area or volume of water within an aquaculture system. It is a critical parameter that influences growth, health, and overall performance of the stocked organisms (Tacon and Metian, 2008).

Value Chain refers to the full life cycle of a product or process, including material sourcing, production, consumption and disposal/recycling processes (WBCSD, 2011).

1.0 Introduction

The global fish production statistics indicate that Nigeria is the highest producer of African catfish and the second-highest producer of farmed fish in Africa (FAO, 2022). Byrd *et al.* (2021, reported that fish is important in the diets of Nigerian households. The country sees the development of the African catfish aquaculture value chain to improve not only nutritional security, but also an industry with high potential to drive job creation and improve the livelihoods of the rural population. What constitutes fish includes finfish (such as catfish, tilapia, bony tongue, snakehead, trunkfish, mullets, etc.) and shellfish (such as shrimps, river prawns, cockles, clams, whelks, periwinkles, oysters, squids, etc.).

Biosecurity in aquaculture refers to the measures and protocols implemented to prevent the introduction and spread of diseases, parasites, and other harmful organisms within aquaculture facilities along the value chain. Maintaining effective biosecurity is crucial for safeguarding the health of farmed aquatic species and ensuring the sustainability and productivity of aquaculture operations.

The application of biosecurity in aquaculture is a shared responsibility where each value chain actor plays a different but critical role in the prevention and spread of diseases. To be effective, biosecurity is necessary at all levels of aquaculture, from the control of the spread of infectious diseases (e.g. viruses, bacteria, fungi and parasites) at an international level, to the development of national controls and the operation of suitable practices at a farm level.

The aquaculture value chain is broad and has the following major actors:

- Input suppliers
- Feed millers
- Hatchery operators/broodstock multipliers
- Fish producers/out-growers
- Fish processors
- Fish marketers
- Transporters

In Nigeria, the major farmed fish species include catfish and tilapia. Production at the farm level involves activities such as pond preparation, stocking, feeding, sorting, water quality management and harvesting. At the hatchery level, practices include handling and selection of broodstock, water quality management, feeding and management of fry and fingerlings of finfish, post-larvae of shrimps/prawns and spats of oysters. Feed production involves the formulation and production of fish feeds using raw materials of plant and animal origin, with additives such as vitamin and mineral premixes, toxin binders, etc. The idea is to produce nutritionally balanced, palatable, digestible, water stable and affordable diets for the fish.

Culture systems include earthen ponds, concrete tanks, make-shift/mobile tanks made of plastic, fiberglass, tarpaulin, glass, metal, or wooden materials. In Nigeria, catfish are grown in earthen ponds and different types of tanks, while tilapia are produced in earthen ponds and cages in dams and lakes. Levels of operation could vary depending on the farmer's capacity to produce on large, medium, small, or micro-scale. Some farmers also operate at different levels of intensity such as extensive, semi-intensive, intensive, and super-intensive. These levels are dependent on the production system, the stocking density, the level of water exchange and the intensity of feeding i.e. whether they are fed complete rations, or the diets are partially or

completely supplemented with natural food in the system. In the culture of the African catfish, extensive production usually has a low stocking density of ≤ 2 fish per m^3 with a pond size that typically ranges from 100 to 1000 m^3 (Ayinla, 1988), mostly homestead or community-based farms, with very minimal water exchange and no feeding besides fertilisation of ponds. Semi-intensive farms have ponds sizes that ranges between 200 to 2000 m^3 with stocking density of 5 – 10 fish per m^3 , such farms operate a moderate or partial water exchange system, feed often but also rely on natural food to supplement the feed. In intensive fish farms (pond size ranging from 20 to 200 m^3), the stocking density is between 35 and 50 fish per m^3 , and water exchange is carried out one to two times daily with fish fed complete diets. Super-intensive fish farms constitute farms that have a stocking density of 200 to 300 fish per m^3 . Water management in super-intensive farming systems is based on the Recirculating Aquaculture Systems (RAS) with the input of oxygen, filtration, and recycling of the water. Feeds in super-intensive systems are complete rations, ideally extruded diets with very high digestibility and water stability.

2.0 Justification

A national biosecurity guideline is crucial for ensuring the protection and safety of humans, animals, plants, and the environment, all of which are interconnected. By preventing the misuse of biological agents, improving knowledge of biosecurity measures, and advancing related technologies, these guidelines will help protect producers, enhance consumer benefits, and ensure food safety in aquaculture.

3.0 Goal

The guidelines are aimed at providing standard operational procedures for different actors in the aquaculture value chain and by so doing, prevent the development and spread of diseases.

4.0 Objectives

The objectives of the national aquaculture biosecurity guidelines are as follows:

- I. To develop "biosecurity" procedures for use in training and educating fish farmers, thereby helping them adopt biosecurity measures relevant to their operations. Note: Experts develop the biosecurity checklist/measures, for farmers to adopt. .
- II. To ensure the welfare and health of fish through the prevention of occurrence and/or spread of disease, and elimination of indiscriminate, inappropriate and misuse of antimicrobials, particularly antibiotics in fish farms, hatcheries, fish market and feed mills.
- III. To develop safe products for consumers through the adoption of best aquaculture practices (BAP) .

5.0 Scope

The biosecurity guidelines cover the entire aquaculture value chain. Biosecurity measures are important as the activity of one actor in the value chain can impact the production or process of the next actor. The guideline therefore helps farmers to prevent disease entry or occurrence, and where disease occurs, farmers should understand procedures followed to contain the disease and prevent it from spreading (in the farm or to other farms). As a result, the scope of these guidelines will cover prevention, early detection, and management of threats to the health and sustainability of aquaculture operations across the value chains.

6.0 Risk assessment

Risk assessment involves the identification of the potential entry points of diseases that pose biosecurity risks on the farm. Some risks identified among input suppliers are activities involving the handling and storage of inputs. If products are not properly stored, they could be infested by pests and pathogens. Potential entry points of disease in feed mills, broodstock farms, grow-out farms and hatcheries include raw materials, fish seeds, feeds, equipment, farm vehicles and water. Other means of introducing disease causing agents into the production systems are humans (farm attendants, visitors, veterinary doctors, suppliers and transporters of inputs to the farm, security guards patrolling the farms, etc.), predators such as birds, reptiles, other animals and flooding. .

7.0 Legal framework for aquaculture biosecurity

Legislative and regulatory framework to establish the legal basis for aquaculture biosecurity measures includes:

- FAO recommends prudent and responsible use of antimicrobials (FAO, 2019 a, FAO, 2019 b and FAO, 2019 c).
- WOA (OIE) prudent and responsible use of approved antimicrobial with strict adherence to withdrawal period for each antimicrobial used (OIE Aquatic Code, 2021).
- EU placement of aquatic animals on the market requires an official veterinary visit twice a year.
- Nigeria – Inland Fisheries (Aquaculture) Regulations (2016) and Animal Disease Control Act (2022), National Aquatic Animal Health Strategy (NAAHS) for Nigeria (2023 – 2027) apply. In addition, Nigeria is chartered to FAO and WOA so recommendations apply strictly.

8.0 Biosecurity guidelines for aquaculture value chain

8.1 Input suppliers

These are members of the aquaculture value chain that provide goods and services such as feeds, raw materials, chemicals, fish nets, fish farm equipment, supplements, etc., to the farmers and other actors in the value chain.

The input suppliers are involved in sourcing, storing, loading, transportation, and delivery of inputs to fish farms. However, depending on the scale of the fish farm operations, the farmers may also visit the input suppliers to buy goods. Service providers include engineers, plumbers, extension agents, trainers, veterinarians, drivers, etc. There are different sources of risks and hazard points which have been identified and the appropriate biosecurity measures which should be applied for disease prevention proffered in **Table 1**.

Table 1: Potential sources of biosecurity risks for input suppliers, hazard points and biosecurity measures

| Potential sources of biosecurity risk | Hazard points | Biosecurity measures |
|---------------------------------------|--|--|
| A. Humans | 1. Contamination of supplies through contacts during handling. | A. Provide adequate information to the suppliers about safe handling, practice infection prevention control (IPC), and water and sanitation hygiene (WASH). |
| | 2. Sourcing and sales of contaminated/expired products. | A. Ensure to check labels to be sure that products have adequate shelf life. B. Employ experienced managers capable of detecting and assuring the quality of inputs. C. Always buy from reputable suppliers. D. Implement Hazard Analysis and Critical Control Points (HACCP) |
| B. Storage | 1.Lack of pallets and poor ventilation leads to development of mycotoxins and rancidity of feed items. | A. Store items in cool and dry places. B. For on-farm feeds, store in dark, cool and dry places. C. Store feeds in stores free from crevices and holes, and with no access to rodents. |

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| | <p>2. Presence of rodents and insect pests.</p> <p>3. Poor hygienic storage and handling practices.</p> | <p>D. Place feed bags on pallets, away from the wall and the ceiling.</p> <p>E. Allow adequate airflow for ventilation.</p> <p>F. Fish feeds should not be stored for more than 6 months from the date of manufacture and adhere to the first-in-first-out (FIFO) principle.</p> <p>G. Rodents and insect prevention and control programme should be put in place</p> <p>H. Maintain clean storage facilities and avoid contamination during handling.</p> <p>I. Implement Hazard Analysis and Critical Control Points (HACCP)</p> |
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8.2 Fish feed millers

Fish feed millers are aquaculture value-chain actors involved in the production of fish feed. They range from small to large-scale commercial fish feed millers. Large-scale commercial fish feed millers import items such as fish meal (as an animal protein source), additives (, lysine, methionine, and other amino acids, premixes etc). Apart from raw ingredients, importers also bring in finished feeds for use by hatchery operators. Raw ingredients used in formulating and compounding fish feed include soya bean meal, groundnut cake, fishmeal, vegetable and fish oils, maize, vitamins and mineral premixes that meet the specific requirements for different fish species and life stages.

Other imported items employed by large-scale commercial feed millers for fish feed processing and packaging include machinery and packaging materials used in bagging feeds.

Operations in the feed mill start from receiving raw ingredients from transporters/input suppliers, followed by cleaning, drying (where applicable) and storage. Following this, the ingredients are weighed and modified by grinding in a hammer mill, mixing the ingredients in a vertical or horizontal mixer and then the dry mash is mixed with hot water or steam for effective pelleting using a pelleting machine or extruder. Then operations like drying, cooling, coating with oil and packaging follow. Different sources of risks and hazard points have been identified and the appropriate biosecurity measures should be applied for disease prevention (**Table 2**).

Table 2: Potential sources of biosecurity risks for feed millers, hazard points and biosecurity measures

| Potential sources of biosecurity risk | Hazard points | Biosecurity measures |
|---------------------------------------|--|---|
| A. Ingredients' sourcing | 1. Supply of contaminated grains and other raw or unprocessed animal materials or products (such as animal carcasses or any parts, animal fat, meat, bones, manure, etc.) used as feed for aquatic animals. | <p>A. Ensure sources of ingredients are clean and well sanitised and only sourced from reputable suppliers</p> <p>B. Ensure mycotoxin free raw materials are supplied for use in the feed mill</p> <p>C. Ensure that only non-rancid animal fat is supplied to the feed mill</p> <p>D. A quality assurance laboratory for testing of both nutritional and microbial quality of raw materials should either be in place or be accessible</p> <p>E. Implement Hazard Analysis and Critical Control Points (HACCP)</p> |
| B. Feed processing | 1. Use of unclean facilities/machinery and equipment for feed processing | <p>A. Implement good manufacturing practices (GMP)</p> <p>B. Always clean all machines before and after use in feed processing</p> <p>C. Check the appearance of finished feeds for texture, colour and odour before bagging.</p> <p>D. Always analyse the proximate composition and microbial load of finished feeds.</p> <p>E. Implement Hazard Analysis and Critical Control Points (HACCP)</p> |
| C. Feed production and packaging | <p>1. Contamination from grease applied to machinery.</p> <p>2. Contamination of incoming feed materials from unclean pre-conditioners and dryers</p> <p>3. Use of old, unclean bags at feed mills.</p> <p>4. Use of raw materials lying on the floor of the feed mills.</p> | <p>A. Feed-millers/attendants/workers must practise IPC and WASH.</p> <p>B. Machinery must be properly cleaned after greasing and before operation.</p> <p>C. Use new bags for all feeds produced (bags must not be reused).</p> <p>D. Maintain proper storage of raw materials and do not use raw materials lying on the floor.</p> |

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| <p>D. Unhygienic environment and feed mill workers.</p> | <p>1. Unclean and bushy environments which harbours rodents and disease vectors.</p> <p>2. Poor sanitation and hygiene among feed mill workers can contaminate fish feed.</p> | <p>A. Fumigate the feedmill and environs at least twice a year.</p> <p>B. All grasses must be cut and maintained properly to deter rodents.</p> <p>C. Fish feed millers must observe the HACCP principles in the feedmills.</p> <p>D. Build a fence around the feedmill to keep out non-feedmill staff.</p> <p>E. Foot and tyre disinfection systems should be installed at the entrance of the feedmill.</p> <p>F. Extractor fans must be used in the feedmill to remove dust and heat.</p> <p>G. There must be a bathroom, toilet and cloakroom for all workers; and ensure the strict use of the mentioned facilities</p> |
| <p>E. Storage and warehousing of raw materials and finished products</p> | <p>1. Poor storage facilities and practices for raw materials and finished feed</p> <p>2. Inappropriate packaging materials</p> | <p>A. Feeds must be stored in cool and dry places, free from dampness and leakages. This is to prevent oxidative rancidity, contamination, and spoilage/decomposition.</p> <p>B. Utilisation of raw materials or feeds should follow a first-in-first-out basis, and only properly dried feeds should be stored.</p> <p>C. All mouldy or rancid feeds should not be used and must be promptly and properly discarded.</p> <p>D. Provide education and training programs for aquaculture producers and suppliers on the importance of using appropriate packaging materials. This can include information on the potential risks associated with inappropriate materials and guidance on selecting packaging options that meet regulatory requirements and industry best practices.</p> |
| <p>F. Disorganised production line</p> | <p>1. Unorganised production-line may interrupt the production process, creating room for pathogenic contamination during production.</p> | <p>A. Always rely on technical advice on factory design, machine layout and process flow to avoid interruption or delays in production.</p> <p>B. Invest in back-up power supply sources and small feed mills should invest in diesel powered pelletizers and gas dryers.</p> |

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| | 2. Break in the production process due to power outage | |
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8.3 Hatcheries and broodstock multipliers

Fish hatchery operations involve the breeding, hatching and rearing of fish in a controlled environment to produce fish fry or fingerlings for stocking aquaculture farms, fisheries or natural water bodies. These operations typically include activities such as selecting broodstock (parent fish), hypophysation, stripping of eggs, collection of milt, fertilisation, incubation, hatching, separation of dead eggs and raising the resulting fish larvae until they reach a size suitable for stocking. The **Figure below** shows the production cycle of catfish.

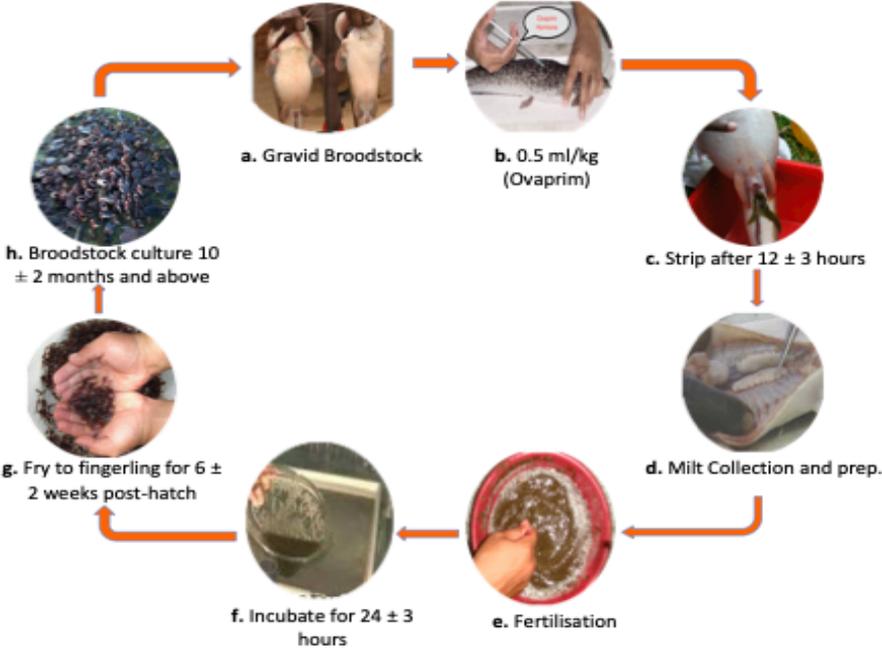


Figure 1: Life cycle of catfish in the hatchery. (Isa *et al.*, 2019).

This process is not similar for tilapia. The males and females are paired for natural egg fertilization and fry collection. The goal of fish hatcheries is to produce healthy and high-quality juvenile fish to support sustainable aquaculture production, conservation efforts and enhancement of wild fish population. There are different sources of risks and hazard points which have been identified and the appropriate biosecurity measures should be applied for disease prevention and control. See Table 3.

Table 3: Potential sources of biosecurity risks for hatchery operators and broodstock multipliers, hazard points and biosecurity measures

| Potential sources of biosecurity risk | Hazard points | Biosecurity measures |
|---|---|---|
| <p>A. Broodstock acquisition B. Eggs</p> | <p>1. Cross-contamination from broodstock to eggs. 2. Eggs could be contaminated with bacterial or fungal pathogens</p> | <p>A. Disinfect all broodstock with potassium permanganate before use for breeding. B. Ensure a salinity of 30-35 ppt for marine shrimp broodstock, for river prawns ensure a salinity of 0-5 ppt for the broodstock</p> |
| <p>B. Fingerling production</p> | <p>1. Inappropriate use of antibiotics in finfish and shellfish hatcheries. 2. Some hatchery operators use antibiotics as prophylaxis. 3. Faulty hatchery design leading to inability to treat a tank separately.</p> | <p>A. To prevent antimicrobial resistance, indiscriminate use of antibiotics should be avoided. B. Adopt strict biosecurity measures and the use of alternative medicine such as probiotics and adhere to good farm hygiene practices.. C. Hatchery design and tank installations should be done under the supervision of a systems expert to avoid design and or installation errors. Each tank should be capable of being isolated from the entire system whenever the need arises e.g. in case of treatment and suboptimal production.</p> |
| <p>C. Point of entry into the hatchery/broodstock facility</p> | <p>1. Indiscriminate entry of humans potentially carrying pathogens on clothes, footwear, and vehicles.</p> | <p>A. Foot dips, overhead sprays and hand wash must be put in place for staff and visitors. B. Coverall (wears) should be provided for staff and visitors at the point of entry.</p> |

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| | <p>2. Introduction of new, stressed, injured or diseased broodstock upon arrival.</p> | <p>C. Prevent introduction of diseased or sick broodstock into the hatchery. D. New broodstock should be quarantined and treated (where applicable) before introduction.</p> |
| <p>D. Equipment and personnel</p> | <p>1. The use of contaminated equipments (fomites) in different tanks.</p> <p>2. Indiscriminate and unprofessional diagnosis and administration of treatments.</p> <p>3. Lack of proper observation of fish (finfish and shellfish) behaviour, symptoms of diseases and disease reporting line.</p> <p>4. Poor record management.</p> | <p>A. Diseased fish (shellfish and finfish) should be immediately isolated, each tank should have its own siphoning hose, nets and bowls.</p> <p>All equipment should be</p> <p>B. washed, disinfected and properly rinsed before and after use. C. Thoroughly clean and disinfect facility between batches of fish seed produced. D. Only veterinarians and qualified personnel are authorised to prescribe, administer and/or supervise the use of antibiotics, medications, vaccines, and chemicals on the farm. E. Educate staff on the normal and abnormal behaviors of fish and shellfish. F. Establish clear and efficient protocols for disease reporting, including who to notify, how to document observations, and the steps to take once disease is suspected. G. There should be a proper reporting line in the event of a disease outbreak and prompt action taken. H. There should be proper record keeping of antibiotics, chemicals, hormones, anaesthesia, etc., used in the hatchery. .</p> |

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| | | I. Keep and regularly update disease and treatment logbooks . |
| E. Environment | 1. Unclean and bushy environment which harbours rodents and disease vectors that may be a source of contamination to broodstock, fry, fingerlings, post larvae and spats | <p>A. Fumigate the hatchery and environs at least twice a year.</p> <p>B. All grasses must be cut and maintained properly to deter rodents.</p> <p>C. Fish farm hatchery operators must observe the HACCP principles at the point of entry into the hatchery environment.</p> <p>D. Build a fence around the hatchery to keep out non-hatchery staff.</p> <p>E. Foot and tyre disinfection systems should be installed at the entrance of the broodstock/hatchery facility.</p> <p>F. Prevent escapes of fish seeds from hatcheries with screens and catchment ponds.</p> <p>G. Treat effluent water and ensure a minimum of 5mg/l of dissolved oxygen before discharge.</p> <p>H. There must be a bathroom, toilet, and cloakroom for all workers.</p> |

8.4 Fish farmers (out-growers)

Fish producers are individuals or entities in the aquaculture value chain involved in the cultivation, harvesting, and sale of fish. Producers can range from small-holder farmers to large-scale commercial aquaculture operators.

Fish grow-out operations involve the rearing of fingerlings/juveniles to a marketable size in controlled/confined environments such as ponds, tanks, cages and raceways. The majority of catfish aquaculture operations in Nigeria are done in earthen ponds. In recent years, tank systems are becoming popular as a result of the peri-urban nature of aquaculture. These tanks range from concrete to fiberglass.. Some productions are indoors in tanks while others are outdoors. Other grow-out operations are done in cages, especially for tilapia production. Cage culture is a method of aquaculture where fish are raised in floating cages placed in natural water bodies such as dams, lakes, rivers or in the coastal areas. A cage system is made up of either metals or polypropylene frames attached to floats and the cage is anchored to the base of a water body, away from the shore. Attached to the frames are nets of specific mesh sizes

required for the grow-out operations. In cage culture, fish are fed manually or automatically and managed within the cages until they reach marketable size. In recent years, the use of raceways at effluents of dams are springing up for the production of catfish. In Nigeria, oysters are farmed in netlon cages suspended on wooden or PVC rafts placed at ideal depths in tidal rivers or ponds. Spats are harvested from the wild, usually from the exposed roots of mangrove trees. The spats are then dislodged from the mangrove roots and are transferred into the suspended cages.

During the grow-out phase, the fish are fed a balanced diet, monitored for growth and health, and managed to optimise their development until they reach harvest size. Key activities in fish grow-out operations include maintaining water quality parameters, managing stocking densities, grading/sorting, controlling diseases, maintaining good feeding regimes and ensuring suitable environmental conditions for optimum growth. The primary goal of fish grow-out operations is to produce healthy and marketable fish for commercial purposes or consumption. The use of aquaculture as a means of livelihood and job creation has led to the creation of several clusters across the country. These clusters range in size and mostly use earthen pond-based systems for operations. Numerous young men and women are brought together, trained and allocated ponds within the cluster. Often, these clusters have a centralised management system, production and sales are managed and regulated. There are different sources of risks and hazard points which have been identified and the appropriate biosecurity measures should be applied for disease prevention. See Table 4.

Table 4: Potential sources of biosecurity risks for fish producers(out-growers), hazard points and biosecurity measures

| Potential sources of biosecurity risk | Hazard points | Biosecurity measures |
|--|--|--|
| A. Points of entry into the fish farm | 1. Indiscriminate entry of humans potentially carrying pathogens on clothes, footwear and vehicles. 2. Unclean canoes used for feeding and monitoring in the cage culture system. | A. Foot dips, overhead sprays and hand wash must be put in place for staff and visitors. B. Coverall (wears) and foot wears should be provided for staff and visitors at the point of entry. C. There should be adequate control of traffic into the farm. D. Carryout daily cleaning and disinfection of boats.. |

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| B. Equipment /facilities used on the farm and farm personnel | <p>1. The use of contaminated fomites in different tanks, ponds, cages and raceways.</p> <p>2. Movement of fish from one section to another section of the facility and during harvest.</p> | <p>A. Diseased fish should be immediately isolated. Each tank or pond should have its own dedicated equipment, such as nets and bowls.</p> <p>B. Ensure strict biosecurity protocols by using separate, disinfected equipment for each section; isolate fish during movement and harvest and thoroughly disinfect all tools and surfaces before and after transfers.</p> <p>C. All equipment should be washed, disinfected, properly rinsed and dried before and after use.</p> <p>D. Thoroughly clean and disinfect facility between batches of fish produced.</p> <p>E. Fish holding and cooling facilities should be readily in place prior to harvest.</p> |
| | <p>3. Indiscriminate and unprofessional diagnosis and administration of medication .</p> <p>4. Lack of proper observation of fish behaviour, disease symptoms and reporting line.</p> <p>5. Poor record management.</p> | <p>A. Only veterinarians and qualified fish health care providers are authorised to administer and supervise the use of antibiotics and other medications, vaccines, and chemicals on the farm.</p> <p>B. There should be a proper reporting line in the event of a disease outbreak and prompt action be taken.</p> <p>C. There should be proper record keeping of antibiotics, chemicals, hormones, anaesthesia, etc., used in the hatchery..</p> <p>D. Keep and regular update Disease and treatment logbook. are .</p> <p>E. Record dates, times, number of fish, average weight of fish stocking density and movement or transfer of fish within facilities.</p> |
| C. Farm management practices employed | <p>1. Use of contaminated water and poor water quality management</p> <p>2. Overfeeding</p> | <p>A. Test water to ensure microbial and physicochemical quality and that parameters are optimum before use and adhere to daily monitoring of water at source and in ponds.</p> <p>B. Maintain a good feeding regime as underfeeding could lead to type I cannibalism and overfeeding could lead to</p> |

8.5 Fish processors

These are actors in the aquaculture value chain that are involved in value addition. Fish processing involves a range of traditional and modern methods, as well as improved technologies, to transform raw fish into various finished products. Fish processing technologies vary widely in terms of equipment type, fuel type, size and processing efficiencies. Freezing, canning, salting, smoking and drying are methods of processing and preserving fish in Nigeria. Smoking is the most popular form of fish processing in Nigeria. It involves the use of various equipment including galvanised iron sheets, drum ovens, black clay ovens, red clay ovens, brick kilns and steel smoking kilns.

The type of fuel used in processing primarily includes , charcoal, briquettes, wood and plant pellets, etc., while some modern kilns rely on electricity and gas. Processed fish products are readily acceptable to consumers. However, there are issues along the processing line which may pose danger to the health of processors and consumers if not addressed. Therefore, adopting and adhering to biosecurity measures in fish processing operations is crucial in providing healthy fish to consumers.

Fish smoking operations begin with receiving the raw fish, weighing and counting, descaling (where applicable), degutting, washing, shaping, skewing or cutting into chunks, salting/spicing (where applicable), drying, smoking (cooking and drying), cooling and then packaging.

Freezing is a method used to preserve fish for extended periods by lowering the temperature below 0 °C. The process involves weighing, cleaning, rapid freezing (blast freezing) and packaging. Blast freezing for 3 hours at -18 °C helps to rapidly reduce temperatures and inhibit metabolic activity and spoilage. This is followed by packaging of the fish before storage in freezers at temperatures below 0 °C. Freezing helps to inhibit the growth of microorganisms, and enzymes, that cause spoilage, thereby extending the shelf life of the fish. Frozen fish can be stored for longer periods without compromising its taste, texture and nutritional value. The packaging materials used in the industry include Styrofoam boxes, cartons, polyethylene bags, plantain/ banana leaves, etc.

There are different sources of risks and hazard points which have been identified in fish processing and the appropriate biosecurity measures should be applied for disease prevention. See Table 5.

Table 5: Potential sources of biosecurity risks for fish processors, hazard points and biosecurity measures

| Potential sources of biosecurity risk | Hazard points | Biosecurity measures |
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| <p>A. Equipment and Personnel</p> | <p>1. The use of contaminated fomites in different fish processing facilities.</p> <p>2. Sharing equipment between farms or different production units can spread contaminants.</p> <p>3. Not adhering strictly to the use of the right equipment and conditions during fish processing and packaging.</p> <p>4. Poor hygiene practices in fish processing facilities</p> <p>5. Sick or infected workers in the processing facility can spread diseases to fish products through direct contact or respiratory droplets.</p> | <p>A. All equipment should be properly cleaned, washed, disinfected, properly rinsed and dried under the sun before and after use.</p> <p>B. Dedicate equipment to specific areas and/or purposes. Where avoidable, do not share processing equipment and where necessary, thoroughly wash and disinfect before use.</p> <p>C. The use of appropriate equipment with the required specifications e.g. stainless-steel smoking kilns in place of mild steel, the use of plantain leaves in place of aluminium foils and polyethylene bags.</p> |

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| | | <p>D. Fish processors must observe the HACCP principles at the point of entry into the processing facility.</p> <p>E. Build a fence around the processing facility to restrict/control access.</p> <p>F. Foot and tyre disinfection system should be installed at the entrance of the processing facility.</p> <p>G. There must be a bathroom, toilet, and cloakroom for changing for all workers. Besides, foot wears and hand gloves should be strictly used on the farm).</p> <p>Food handlers should be tested every six (6) months to ensure healthy conditions and identify potential sources of infection.</p> |
| <p>B. Processing</p> | <p>1. Delay in commencement, and completion of processing.</p> <p>2. Cross-contamination of fresh fish with deteriorating fish.</p> <p>3. Incomplete de-gutting, cleaning, smoking (high moisture content >10 %) and freezing (high temperatures in frozen fish > 4 °C).</p> | <p>A. Timely/prompt commencement of fish processing operations as delays could lead to increased microbial activities and decomposition.</p> <p>B. Decayed or contaminated fish should be immediately sorted and properly disposed of before processing.</p> <p>C. Attention should be paid to all processing steps and adequate supervision and quality check should be in place at all steps. All smoked fish should</p> |

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| | | contain <10% moisture and all freezers should operate at sub-zero temperatures. |
| C. Packaging and Storage | <p>1. Inadequate and unhygienic packaging materials or techniques can expose fish products to contamination during storage and in transit.</p> <p>2. Poor hygiene of the storage facilities can favour pests resulting in contamination of processed fish.</p> | <p>A. Select food-grade packaging materials and ensure packed fish are properly sealed and stored in cool and dry places.</p> <p>B. Packaging should be carried out under satisfactory conditions of hygiene, such as improved ventilation, screened windows, smooth tables, insect proof cabinets and walls, water and dust-proof conditions.</p> <p>C. Avoid the use of chemicals and pesticides as insect deterrents and preservatives.</p> <p>D. Storage for sales should follow a first-in-first-out basis. Processed fish must be stored appropriately to prevent contamination by pests and rodents.</p> |
| D. Waste management | <p>1. Improper disposal of biological waste (e.g., fish scraps, guts, scales and other by-products)</p> <p>2. Improper disposal of effluents (e.g. blood and wastewater).</p> <p>3. Improper disposal of packaging materials (e.g. cartons, leaves, bags etc.)</p> | <p>A. Appropriate disposal of fish wastes, away from the processing facility.</p> <p>B. Use covered, water-tight receptacles to prevent leakages, foul smell and pollution of waterways.</p> <p>C. Dispose of waste promptly and responsibly.</p> <p>D. Treat effluent water to deodorise and reduce contaminants before discharge.</p> |

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| | | E. Use biodegradable packaging materials and properly dispose of waste from the packaging material |
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8.6 Marketers

Marketers are actors in the aquaculture value chain involved in connecting producers with different categories of middlemen and consumers by facilitating the distribution and sales of aquaculture products. There are different categories of marketers; agents/middlemen, wholesalers and retailers. The agents go to the farms/clusters to buy the fish in bulk from out-growers and get it transported to the fish markets where they distribute to the wholesalers and retailers. Sometimes, the wholesalers may also buy directly from the fish farms and distribute to other wholesalers, retailers, processors and consumers. The wholesalers have outlets in major fish markets where they sell to retailers and sometimes directly to consumers.

In Nigeria, wholesalers source fish from different states mostly in the North-central and the South-west and transport them to major cities in the North (e.g. Abuja, Kaduna, Kano, Jos and Makurdi), the South-east (Onitsha, Aba and Enugu) and the South-south (Port Harcourt, Delta and Bayelsa).

Depending on the destination market, fish type (live/frozen/smoked), different means of packaging are employed for moving fish from farm to market. For instance, during the harvest of live African catfish for the market, fish are sorted into different sizes and weighed into 80 L bowls containing 25 kg of fish and 15 L of water. About 3-5 drops of palm oil are added and the bowl is covered with sacs tied with a rubber band; 18-seater buses carrying 50 of these bowls which are transported to other states for sales. At distribution points or centres, live/frozen/ smoked/dried fish are received, weighed and sorted by marketers and distributed for sale in major fish markets. Retailers market fish in smaller neighbourhood markets, food markets, small processors like restaurants, pepper fish joints and some hawk processed fish.

When transferring fish from farmers to marketers and eventually to consumers, several safety and quality risks may arise such as exposure to extreme temperatures (leading to fish spoilage, bacterial growth and quality deterioration), rough handling of fish during loading, unloading and transfer (leading to physical damage, bruising and stress to fish), exposure to contaminants due to failure of packaging materials (e.g. water leakage, cross-contamination due to mixture of different sources of fish), administration of chemicals and drugs to prolong the life/shelf-life of fish. Addressing hazards in this value chain requires proactive risk management strategies like best practices, training of personnel and compliance with regulatory requirements. See Table 6.

Table 6: Potential sources of biosecurity risks for fish marketers, hazard points and biosecurity measures

| Potential sources of biosecurity risk | Hazard points | Biosecurity measures |
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| A. Points of entry into the fish farm | 1. Indiscriminate entry of humans (marketers) into production areas. | A. There should be designated meeting and collection points for marketers and customers on the farm |
| B. Handling and Transportation | 1. Unclean/contaminated equipment and collection bowls used to collect fish by marketers. 2. Unhygienic handling practices can cause mortality in the fish. | A. Fish handlers must ensure that they are properly kitted and that they maintain good hygienic practices throughout the transportation process. B. Ensure the use of clean water and collection bowls/containers by marketers at collection points to prevent contamination and spread of disease. C. Ensure proper handwashing and proper washing of all handling and carrying equipment. D. Handle and kill fish humanely. |
| C. Point of sale contamination | 1. Mixing different fish species and fish from different farms at the market leads to cross-contamination 2. Contamination of left-over fish which has not been sold due to unhygienic display strategies. 3. The use of antimicrobials and chemicals post-harvest and at the point of sales | A. Avoid mixing fish from different farms in the same container for transport, storage and/or sales. B. Train fish marketers on best practices when handling, displaying and sales of live/dry/smoked/frozen fish. C. Do not use antimicrobials and/or chemicals to prolong or preserve life/shelf-life of fish. |
| D. Storage | 1. Proliferation of pathogens in stressed fish exposed to high/extreme temperatures in the market. | A. Ensure to have access to ice blocks and alternative power sources for refrigeration of fresh and unsold fish. |

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| | 2Use of chemical agents (eg. pesticides,insecticides etc.) to prolong the shelf-life of smoked fish. | B. Shops involved in sales of smoked /dried fish must have dehumidifiers and must be free from leakages, damp and access by rodents. C. Do not use chemical agents to prolong the shelf-life of smoked fish. |
| E. Record keeping and traceability | Inability to trace fish back to their source can hinder disease control. | A. Maintain records of fish sources, harvest dates, and handling practices. B. Label fish with relevant information for traceability. |

8.7 Transporters

Transporters are service providers in the aquaculture value chain involved with the movement of live aquatic organisms, aquaculture inputs, harvested and processed products to the market. The transport value chain involves activities aimed at ensuring the efficient, safe and timely delivery of fish inputs and products while maintaining product quality and integrity from farm to fork. Transportation involves activities such as pre-transport preparation, transport documentation and compliance, packaging (inputs/live fish/ aquaculture products), handling and loading, route planning, quality control (water quality management and temperatures during live fish transport) during transportation, offloading and delivery.

In Nigeria, the modes of transportation used for moving fish, inputs, products, etc. from one location to another include road (refrigerated trucks, insulated containers and coolers in vans and cars and cooling systems in carts), air (for high-value and time-sensitive aquatic products) and sea (for bulk items such as imported feeds, raw material, equipment, other consumables, etc.).

Several challenges and potential entry points of diseases can pose risks to the quality, safety and welfare of aquaculture input supplies and products e.g. unclean vehicles, improper handling and loading practices, stress in live fish, water quality management issues, non-compliance with regulatory requirements, weather, environmental factors, etc.

These challenges can be prevented through effective risk management strategies such as proper planning, monitoring and management of transport logistics, compliance with regulatory requirements, and adherence to product handling and quality control standards. These include but are not limited to, implementing quality control procedures, investing in suitable packaging technology and training personnel in handling and biosecurity protocols. There are different sources of risks and hazard points which have been identified in the transportation component of the value chain and appropriate biosecurity measures should be applied for disease prevention. See Table 7.

Table 7: Potential sources of biosecurity risks for fish transporters, hazard points and biosecurity measures

| Potential sources of biosecurity risk | Hazard points | Biosecurity measures |
|--|---|--|
| A. Vehicles | <p>1. Contamination and infection of supplies and products during transportation due to poor hygiene of the vehicles.</p> <p>2. Use of vehicles without cooling systems</p> | <p>A. Vehicles should be properly cleaned and sanitised before and after every delivery.</p> <p>B. Wastes removed from vehicles should be properly disposed of.</p> <p>C. Educate the transporters on the risks of contamination.</p> <p>D. Ensure vehicles used for transporting aquaculture supplies/products meet compliance requirements e.g. use of refrigerated trucks, insulated containers and coolers in trucks, cars, vans, trains, sealed oxygenated bags for fish seeds transport, etc.</p> |
| B. Personnel | <p>1. Delay due to unplanned documentation and compliance requirements for transporting, long distance and breakdown of vehicles during delivery of aquaculture supplies and products.</p> <p>2. Poor handling during packaging (where applicable), loading, offloading and delivery of inputs/live fish/ aquaculture products.</p> | <p>A. Educate transporters on the risk of pollution due to delays from non-compliance to regulatory requirements for transporting inputs/live fish/ aquaculture products.</p> <p>B. Ensure that the vehicles meant for transporting fish, meet the regulatory requirements for transporting inputs/live fish/ aquaculture products.</p> <p>C. Use properly serviced vehicles equipped with battery aerators and cool boxes.</p> <p>D. Transporters must practise IPC and WASH.</p> <p>E. Use clean packaging materials (where applicable) for all supplies/ products.</p> <p>F. Load/offload/deliver, inputs supplies/live fish/ aquaculture products separately to avoid cross-contamination.</p> <p>G. There should be adequate supervision of all the processes involved in transportation of inputs/products in aquaculture.</p> |

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| <p>C. Quality control during transportation</p> | <p>1. Contaminated water due to pollution and the build-up of metabolites during the transport of live fish leads to stress and disease outbreaks.</p> <p>2. Temperature fluctuations</p> <p>3. Moist containerized vessels for the transport of aquaculture inputs/ supplies resulting in contamination</p> | <p>A. Avoid overstocking live fish seed in transport vats during transportation. Fingerlings of catfish should not exceed 1,000/50L jerrycan containing 20L of water. Juveniles of catfish should not exceed 500/50L jerrycan containing 20L of water. Tilapia should not exceed 1,000 fingerlings per oxygen bag containing 15 L of water. These numbers are for transportation of live fish seed to distances of not more than 400 km.</p> <p>B. Stop feeding fish at least 24 hours before transportation.</p> <p>C. Antifoaming agent (e.g. palm oil) and antistress (e.g. glucose) used during transportation should be acceptable, non-hazardous and recorded.</p> <p>D. For live fingerlings, spats and post-larvae, 22°C - 26°C temperature is recommended. For broodstock 22°C-28° C is recommended.</p> <p>E. Ensure that live fish are transported early in the morning or late in the evening to avoid temperature fluctuation.</p> <p>F. Dry aquaculture inputs should be transported in cool and dry containers/vessels, free from leakages, damp conditions and corrosion.</p> <p>G. De-humidifiers can be used in very humid weather conditions both in the transport and storage rooms.</p> |
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8.8 Water quality issues

The first point of call whenever there is an outbreak of disease is to check the water quality. Physicochemical parameters of water greatly affect the survival, metabolism, growth and health of fish. Of major concern are parameters such as temperature, dissolved oxygen, pH, ammonia, nitrite, sulphide, hardness, total dissolved solids and conductivity. There are optimum levels of each of these parameters and outside these optimum, each parameter causes harm to the fish in different ways and some together, causes toxicity and mortality. Below 20°C, *Clarias gariepinus* stops feeding and dies at sub-18°C. Below 2 mg/l of dissolved oxygen, *C. gariepinus* stops feeding and cannibalism increases due to increased aggression and thus, mortality. At low pH (below 6) ammonia toxicity increases in fish tanks, hence, high rates of mortality. Changes in water quality outside the optimum ranges stresses the fish, lowers their immunity and predisposes them to diseases. Table 8 provides a list of critical physicochemical parameters of water and their optimum ranges.

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