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Full Length Research Paper

Food safety - related control measures in emerging aquaculture enterprises in sub-Saharan Africa: Compliance of Uganda's operations against international market requirements

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Selected commercial aquaculture enterprises in Uganda were evaluated for compliance with internationally recommended food safety-related control measures. Food hazard control measures at potential critical control points of: farm siting, farm facilities and premises, and facilities for feed processing and storage, chemical storage, drug storage and waste storage were evaluated. Requirements for traceability, legal and certification, standard sanitation operating procedures and food safety skills for farm workers were the other measures evaluated. On a scale of 0 - 5 where 0 denotes none, 1 very low, 2 low, 3 acceptable, 4 almost total and 5, full compliance, the majority of control points evaluated had average scores below 3, a minimum acceptable level of compliance with international guidelines. Feed processing and storage areas were the most deficient of the potential critical control points. Other significant deficiencies occurred in requirements for traceability of fish and use of on-farm standard sanitation operating procedures. Veterinary drug use, a common problem with aquaculture exports, was not an issue since none of the farms was highly intensive – a practice that would increase the risk of infestation of fish with pathogens and raise the need for use of drugs. The compliance gap requires food safety policy and practice interventions in Uganda and other sub-Saharan countries that plan to export products to highly regulated markets like in the European Union.

Key words: Uganda, food safety, control measures, aquaculture compliance, sub-Saharan Africa, international market requirements.

INTRODUCTION

Food safety of fishery products from aquaculture like other on-farm operations has received limited regulatory oversight in the past years (WHO, 1999). This is mainly because aquaculture exports to markets in industrialised economies like in the European Union (EU) and the United States (US); and the requirements for strict food safety controls in the entire value chain from "farm-to-fork" in those markets are a recent phenomenon. Aquaculture on a large scale for export is a relatively new industry which began in some Asian countries more than two decades ago. Even in Asia the initial exports

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encountered food safety problems involving chemical and microbiological contaminants that hampered trade opportunities. Many regulatory issues aimed at controlling food contamination during on-farm operations both for products of animal and plant origin exist in US, EU and other markets in industrialized economies. However, because aquaculture's importance is growing increasingly in international trade, some specific regulations are emerging to regulate the unique features of aquaculture practice especially in the EU. Aquaculture is different from wild fish harvesting since the fish are produced under controlled conditions of containment in ponds with various feeds and chemical inputs added in the production systems. Under these conditions, there are unique risks for chemical and microbiological contamination of these products - the common hazards normally associated with aquaculture practice being residues of chemicals and veterinary drugs, as well as contamination with pathogenic bacteria and parasites (WHO, 1999).

Control of hazards in aquaculture is of significant importance because, once introduced during the fish rearing stage, the hazards may not be eliminated or reduced by the subsequent processes in the chain and in fact may increase the risk of spread (Reilly and Käferstein, 1997). Application of hazard management tools to avoid use of potentially contaminated inputs, implementing adequate hygiene and sanitation programmes, operating in accordance with regulations issued by national regulatory authorities and providing appropriate education and training to farm workers among others are important steps that farms can take to produce safe products that meet requirements of the most stringent markets like the EU and US (Costello et al., 2001; Jahncke and Schwarz, 2002).

Food safety control in aquaculture has been a subject of on-going interest in the world since 1999 when World Health Organization, Food and Agricultural Organization (FAO) in collaboration with the Network of Aquaculture Centres in Asia - Pacific (NACA) organized an expert panel that resulted in the report on food safety issues in aquaculture (WHO, 1999). In 2006 these efforts were re-ignited by FAO/NACA and other donors in a series of meetings and events that culminated into the February, 2008 expert panel on development of international guidelines for aquaculture certification (FAO/NACA/SCA/DFID, 2008). Final guidelines have since been issued (FAO, 2009). The guidelines set minimum substantive requirements and criteria for granting certificate of aquaculture system, practices or products. The minimum substantive requirements address food safety, social and environmental issues, and animal health and welfare (FAO, 2009).

Already, most of the substantive issues in international aquaculture certification guidelines are incorporated in code of practices for aquaculture industry developed by joint effort of FAO and WHO. These issues are largely based on hazard analysis critical control points (HACCP) principles (FAO/WHO, 2003), the FAO/WHO recommendation on food safety issues in aquaculture (WHO, 1999) and regulations of markets in US, EU and the global good agricultural practice (Global GAP) (USFDA, 2001; EC Regulation. No. 852/2004; Global GAP, 2007), which means international trade with those markets, may be conditioned to achievement of the equivalent standards.

Developing countries in sub-Saharan Africa like Uganda have lessons to learn from their Asian counterparts, which to a large extent have substituted their capture fishery export with aquaculture products, on how to promote and target aquaculture exports to major markets in the EU and other industrialised regions. Prior to successes registered by Asian countries, their aquaculture entrepreneurs faced a number of food safety-related challenges including export ban and restrictions, requiring them to produce aquaculture products in accordance with international recommendations (Johnston and Santillo, 2002; Lupin, 2005; Allshouse et al., 2002; Deqing, 2007). Asian and other aquaculture successful developing countries overcame the food safety crises by progressively implementing codes of practices for responsible farming which included guidelines for food safety covering general farm management and registration, and certification of farms (Regidor et al., 2007; Suplicy, 2007).

Although, some countries like Zimbabwe and Gambia have been exporting limited quantities of aquaculture products to Europe for some years, interest of exporting aquaculture products to major markets in industrialised world has very recently grown considerably in sub-Saharan Africa. It is therefore not surprising that although certification and safety regulation for aquaculture has been the subject of growing interest to many countries in the world, little is documented about the experiences and on-going efforts in sub-Saharan Africa. Countries in sub-Saharan Africa like Uganda that are planning to export aquaculture products to industrialized countries, face a challenge of instituting adequate control measures to eliminate or reduce the hazards in fish products to acceptable levels to meet the expectation of consumers and regulatory requirements for exporting to prime markets in Europe, United States, Japan, Australia and other markets in developed countries.

A number of sources of food hazards with significant potential for increasing risk for contamination of the products have been identified in Uganda's commercial aquaculture production chain (Bagumire et al., 2009a). Aquaculture practices of site selection, fry/fingerling selection, animal husbandry, feed selection and usage, and post harvest practices among others could potentially increase risk for hazards. Hence, there is need to institute adequate control measures in the operations and ensure that hazard contamination is eliminated and/or reduced to acceptable levels.

This study aimed to evaluate management practices

undertaken in emerging commercial fish farms in Uganda against food safety control measures recommended by international markets. The study findings would guide aquaculture entrepreneurs and regulatory authorities in Uganda and other countries in sub-Saharan Africa operating under similar production conditions in the determination of how close the farms are to meet the full compliance with international market requirements.

MATERIALS AND METHODS

Research tools and design

An integrated checklist for food safety in aquaculture products covering five themes: hazard control measures at potential critical control points, requirements for on-farm records and traceability, policy legal and certification standard operating procedures, and food safety skills of farm workers was prepared and used in the evaluation. The checklist elaborated the ideal food safety control measures on various points in the production chain provided in international aquaculture certification guidelines (FAO, 2009), FAO and WHO recommendations and standard code of good hygiene practices for aquaculture (WHO, 1999; FAO/WHO, 2003), recommendations of EC regulation No. 852/2004 on hygiene requirements of on-farm production of food animals, USFDA (2001) guidelines for hazard control for fish and fishery products and the relevant sections of Global GAP (2007) checklist for compliance with integrated aquaculture assurance.

The thematic area of potential critical control points (CCPs) included control points (CPs) of farm siting (CCP1), farm facilities and premises (CCP2), feed processing areas (CCP3), feed storage facilities (CCP4), chemical storage (CCP5), drug storage (CCP6), and waste storage (CCP7). Traceability and records (T and R) thematic area was made up of six CPs concerned with traceability of fish and feeds. The thematic area for policy, legal and certification requirements covered policy and legal conditions that farm operators are required to comply with. Standard operating procedures included standard sanitation operating procedures (SSOPs) applied on the farm as evidence for implementation of good aquaculture practices (GAqPs). The thematic area on skills of farm workers focussed on establishing the training, experience and skills of farm workers in management of food safety.

The compliance for each of the CPs at the farms was evaluated against the ideal measures based on single or multiple control measure(s) for the CP identified from the international recommendations and guidelines. Those control measures were in turn generated from a single or multiple recommended conditions (RCs) needed to achieve the measures. The RCs for each control measure in the CPs in the entire aquaculture chain were established and included in the checklist. The checklist was developed with a scale of scores for each of the RCs from 0 to 5 where five denoted full compliance and zero non-compliance. Degrees of partial compliance were also categorized based on the data obtained (4: almost totally compliant; 3: acceptable compliance; 2: low compliance and 1: very low compliance).

Selection of fish farms and sampling

Ten fish farms were selected from a list of 25 commercial fish farms in Uganda regarded as having the potential for future export of aquaculture products. The selection of the study fish farms took into consideration the four main geographic regions in Uganda, the distribution of the farms in the regions and the different potential sources of hazards impacting aquaculture. Farms were randomly chosen from the central (4 out of 11), west (2 out of 5), north (2 out 4) and east (2 out 5) regions, respectively.

Survey of on-farm facilities and practices

The inspection approach recommended by Global GAP (2007) for control points and criteria for compliance with farm assurance was adopted in surveying the farm facilities and practices. The selected commercial farms were visited and meetings held with the farm managers and/or workers and owners depending on their availability. During the visit, a tour of farm and other aquaculture facilities including fish ponds, fish tanks, hatcheries, feed stores, feed processing units, chemical stores, fish stores, fish slaughter areas, waste storage areas, water reservoirs and water sources was conducted under the guidance of farm workers and/or managers and/or owners. During the tour of the farm areas important observations related to the study were recorded.

After the tour a question and answer (Q&A) session was held with managers and/or farm workers and owners where the different control measures observed at the different control points were explained by the farm managers and scored. Using separate checklists, the scoring was carried out by two individuals who had acquired relevant training and experience in aquaculture and food safety management on the farm and use of the checklist. They awarded the scores to the control measures after observing and understanding practices and facilities that constituted each of the control points at the farm. The Q&A session was followed by an in-depth discussion in which clarifications were sought from the farm workers. The clarifications and other remarks were appropriately recorded. After going through the checklist with the farm staff, the two people who were scoring met to harmonize their scores into one set of results on the checklist. In the cases where consensus was not reached, the average of the two scores for each of the control measures were used.

Data analysis

The scores obtained from all the 10 farms were analysed using appropriate software (Statistical package for social scientists - SPSS). To establish the compliance for each of the farms, the scores for RCs for each of the control measures on the CPs were added together and an average score determined as the score for that control measures on a particular farm. To establish the level of compliance among all the 10 farms, the scores for control measures under each CP from the different farms were tallied together and the average determined for the control measure (CM) for a particular CP. To establish the compliance of CPs in the entire aquaculture chain (all farms summed together), average score of the CMs in each CP were tallied together, summed up and overall average scores for all CPs at all the farms obtained.

RESULTS AND DISCUSSION

Compliance of potential critical control points (CCPs) in the aquaculture chain

Out of seven potential CCPs evaluated, only two (drug storage area and farm siting) (28.6%) had overall average compliance score above 3, meaning that five control points (71.4%) had too low a compliance to be acceptable for international trade (Figure 1). The high score obtained for the drug storage is explained by the

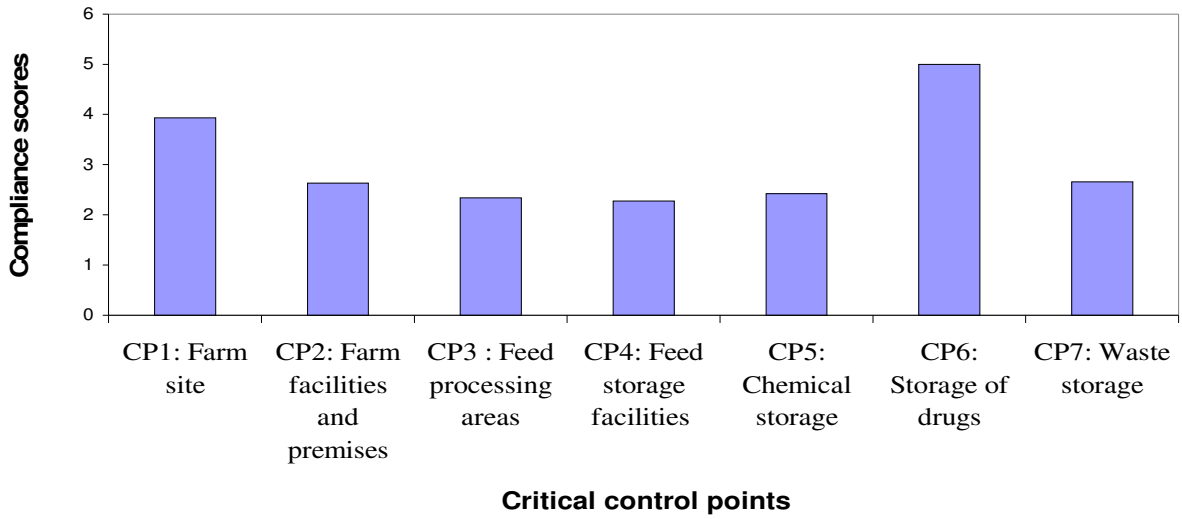

Figure 1. Compliance of critical control points in aquaculture chain.

score obtained for the drug storage is explained by the fact that none of the farms used veterinary drugs and thus was no risk related to handling, storage or treatment of drugs in the fish. This finding is of great significance to Uganda's and other sub-Saharan countries' potential for export of aquaculture products to markets in industrialised countries like the EU and the US where drug residues is a major regulatory issue. This though may be a temporary situation in Uganda, given that the aquaculture industry is expected to develop substantially. Fish health problems associated with intensive aquaculture and frequent use of the ponds is anticipated in the near future, which would require drugs to be introduced. When this happens the situation will need to be reviewed to see how well the farms have effective practices for aquaculture drug use and storage to be compliant with international requirements. Farm siting was the other CCP where a relatively better average overall score of 3. 94 ± 0.9 was obtained denoting fairly acceptable compliance. The ideal condition for this CP would be to have the farm site that is free of potential sources of contamination and having pond water that is not acidic with pH > 7.

The good compliance score observed for farm siting (CCP1) is an indication that farms had instituted measures to mitigate the impacts of potential sources of contamination of pond water such as agrochemical sprays in the neighbourhoods, industrial, municipal and domestic sewer inflows and effluents from industrial processing, metal works, or chemical and oil spillage at the farm. Some of the mitigation measures observed included: digging trenches around the farm to divert and stop the run-offs from nearby catchment areas from entering the ponds and construction of settling reservoirs where potential contaminants are removed by natural means through sedimentation before the water is allowed to enter the ponds. The test for acidity on the pond water showed that 7 out of the 10 farms complied with pH required range (> 7), meaning that there was low risk of heavy metal residues in pond water since the pH would not allow the dissolving of metal complexes. The good compliance score of farm siting CCP is further illustrated by the fact that 2 of the farms surveyed had their CMs obtaining full compliance score (Score = 5), and none of the farms had their CMs with score of zero (score = 0) (Table 1). The lowest overall score among the 7 CCPs was for the feed storage facilities (CCP4) (Figure 1) with overall average score of 2.28 ± 0.7. The main problems at CCP4 were in feed stores where 8 of the 10 farms' feed stores were accessible to unauthorized persons. Feed containers in 7 farms were not clearly labelled to facilitate traceability, 3 farms did not have separate facilities for storing different types of feeds and one of the farms kept feeds that were out of date (Table 1). Also, the feed storage facilities scored low because those farms had no separate storage facilities for different feeds and in some farms fish feeds were being kept together with other potentially hazardous materials and items such as spray pumps for agro-chemicals, the chemicals themselves and other domestic items including human food. They were also stored in inappropriate packaging materials and not kept on raised racks, hence, raising the potential for their contamination from either wet ground or accidental spillage of chemicals in containers. Other issues were: feed storage areas having no restricted entry of unauthorized persons and feed containers not being labelled. The lack of label information meant that staff not familiar with feeds could feed the fish with the wrong products, since specific feeds are meant for particular species raised in separate ponds. This lack of labels could create a risk for cross contamination.

Other problems identified were in chemical storage areas (CCP5) where access restrictions to non-farm staff were lacking in 9 of the 10 farms which would lead to

Table 1. Compliance of potential critical control points on fish farms (n = 10).

Potential control points (CP) and control measures (CM)	Number of recommended conditions	Mean scores of control measures (CM) (n = 10)	Minimum score	Maximum score	Number farms where CM scored zero	No of farms where CM scored 5
CCP1 farm site						
CM 1.1: Farm site free of potential sources hazards	4	3.93	2.75	5.00	0	2
CM 1.2: water pH of water not acidic	1	3.95	0.50	5.00	0	7
CCP2 facility premises						
CM 2.1: Buildings and ponds/tanks maintained in state of good repair	3	4.22	3.43	5.00	0	2
CM 2.2: Site is tidy and well organized	3	2.84	1.00	4.33	0	0
CM p2.3: There is mechanism for traceability of fish at the farm	4	2.03	0.00	3.00	10	0
CM 2.4: Prevention of possible contamination through unrestricted entry of personnel	3	2.41	0.50	4.83	0	0
CM 2.5: Presence of predator control methods that are not destructive	2	1.65	1.00	2.50	0	0
CCP3 feed processing areas						
CM 3.1: Containers and equipment used for measuring and mixing feeds used only for specific purposes	2	2.23	1.00	4.00	0	0
CM 3.2: Equipment and procedures used minimize the risk of feeds being contaminated by chemicals	1	2.45	0.00	5.00	1	2
CCP4 feed storage facilities						
CM 4.1: Availability of separate facilities for storing different feeds	1	2.0	0.00	5.00	3	1
CM 4.2: Feed store restricted to unauthorized persons	1	0.40	0.00	2.00	8	0

Table 1. Contd.

CCM 4.3: Storage facility protects feed from weather, pests, and chemical or physical contamination	4	2.54	1.25	4.50	0	0
CM4.4: Feed stored in appropriate packages off the ground	2	2.35	1.00	5.00	0	1
CM4.5: Feed containers clearly labelled to facilitate traceability	1	0.80	0.00	3.00	7	0
CM4.6: Feeds in storage are within their shelf life (use by date)	2	4.10	0.00	5.00	1	7
CM4.7: Different feeds/ ingredients physically separated from one another	2	3.75	1.50	5.00	0	5
CCP5 chemical storage						
CM5.1: Entry to chemical stores restricted to unauthorized person	1	0.50	0.00	5.00	9	1
CM5.2: Storage facility sited in such manner that minimizes the likelihood of contamination of fish	2	3.1	1.50	5.00	0	2
CM5.3: Chemicals stored in appropriate containers that are clearly labelled to facilitate traceability	3	3.78	1.50	5.00	0	3
CM5.4: Storage site for chemicals is tidy and well organized	3	3.60	1.67	5.00	0	3
CM5.5: Facilities and equipment for measuring and mixing chemicals only used for specific purpose	2	2.95	0.00	5.00	0	3
CM5.6: Existence of an inventory of all chemicals available at the facility	2	1.60	0.00	2.50	0	0
CM5.7: Emergency procedures clearly posted within chemical storage facility and include contact number in case of accident	3	1.48	0.00	5.00	2	1
CCP6 drug storage						
CCM6.1: Medication securely kept to avoid contamination with other inputs, waste and fish	3	5.00	5.00	5.00	0	10

Table 1. Contd.

CM6.2: Only legal and approved medications are in use at the facility	2	5.00	5.00	5.00	0	10
CCP7 waste storage						
CM7.1: Waste material and products stored or disposed off properly to avoid cross contamination of ponds and environment	1	3.40	0.00	5.00	1	4
CM7.2: Waste clearly separated from other farm products and properly disposed off	2	3.48	1.00	5.00	1	2
CM7.3: Existence of measures to avoid criss-crossing and cross contamination through human and product flow	2	1.10	0.00	2.50	0	0

which could lead to contamination of feeds to chemical and microbial hazards. There was lack of protocols for managing emergencies and accidents that could arise from chemical usage in 2 of the farms. There was a problem in waste storage areas where one of the farms did not store or dispose of the farm waste properly to avoid potential cross-contamination of the ponds, tanks and other fish handling surfaces and the waste was not properly segregated from fish feed products.

These non compliances could result in high fish and feed contamination levels sufficient to prevent access of products to the markets like the EU where specific hygiene regulations for animal feeds exist (EC Regulation. No 183/2005).

During the interviews, most farmers indicated that food safety issues are not well understood. The technical advice received from extension service providers mainly focused on production and environmental issues, which explains the non compliances. The farmers were not sensitized about the importance of food safety in farming operations. This can also be blamed on lack of industry manuals that emphasise best practices for food safety in aquaculture.

Compliance of fish farms with traceability requirements

Relatively high compliance scores were obtained for control points related to thematic area on T and R with overall compliance scores for most of the CPs > 3 (Figure 2). The highest scores were obtained for fish health records (4.45 ± 0.8) and production and marketing records (4.25 ± 1.6). With exception of one CP of on-farm traceability of fish which obtained the lowest overall score of 2.5 ± 1.6, other CPs obtained fairly good scores too (that is, records and traceability of fish feed (3.58 manufactured feed (3.96 ± 1.13) and records of ± 1.01), records and traceability of on-farm feed and feeding (3.50 ± 2.11).

Even though the majority of control points under this section were fairly compliant as mentioned above, generally the farms cannot be considered to comply with the requirements, since the CP of traceability of fish which are the main products of the farms, scored low. This is because, in case of food safety crisis, it would be difficult to trace where the fish product encountered the food hazards in the chain. It should be noted however, that most of the farmers interviewed did not understand the link between records and traceability measures and food safety. This clearly demonstrates the lack of sensitisation and awareness regarding food safety in an upcoming sector in Uganda and very likely, most sub-Saharan countries with similar aquaculture production conditions. Even for CP on fish health records which scored highly, farmers were keeping fish health records for economic reasons rather than for health and safety reasons mainly

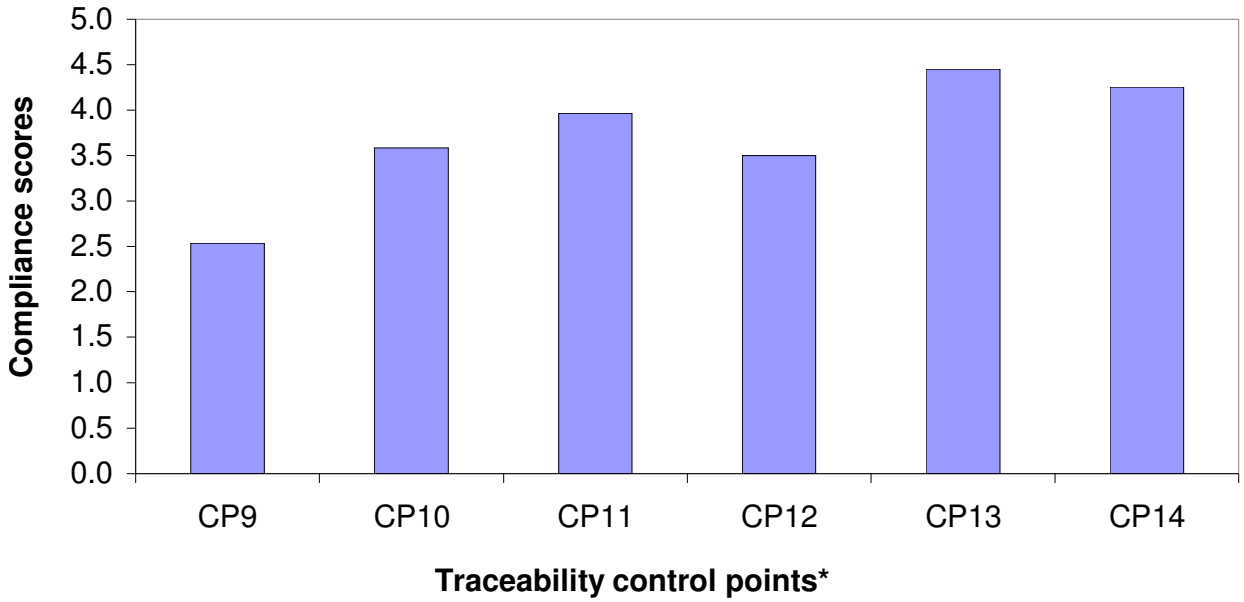

Figure 2. Compliance of traceability controls at the farm. *CP 9 (Records and traceability of fish), CP10 (records and traceability of readily manufactured feeds), CP 11(records and traceability of on-farm manufactured feeds), CP12 (Records of feeds and feeding traceability), CP13 (Fish health records), CP 14 (Production and marketing records).

as a measure to keep track of stock levels in their facilities. And for production and marketing, records were kept as part of business practice to facilitate them in monitoring expenditures, sales, profits and losses; but not for traceability purposes.

Traceability information goes beyond data generation for business management. Traceability has two major components: logistics and safety (Todd and Caswell, 2008). It requires collection and maintenance of specific chain-related information that is essential for effective food safety controls at the farm and beyond. There is great need to train and sensitize farmers in food safety-related traceability measures. The low score obtained for CP of on-farm traceability of fish was because the majority of the farms (8 out of 10) were not keeping details of fish species being raised in their ponds and/or tracking their movements within the ponds and tanks by recording date and batch of fish (fry and fingerlings) received from their sources or those moved from one pond/tank to the other (Table 2). In two farms, unique identity (batch) codes were not used, and therefore it would be difficult to link any specific treatments or feeding regimes to a particular lot of fish. Unique batch codes are essential for proper management of batch information that is important for traceability. The problem associated with lack of management of batch information is the potential for cross-contamination that may arise from the likely over-use of feed, drugs and/or other treatments to the same fish due to the failure to logically document and plan specific actions. This failure to maintain the details of the fish held in ponds, and their treatment and movements at the farm could result in potentially unsafe products being sold to consumers. One farm did not have any documented history of fish transfers from suppliers and within the ponds/tanks at the facility, meaning that for such fish their sources were unknown. If any of these fish products are targeted for recall while in market because of food safety-related problems, this could affect all the rest of the farm products, not just the batch tested.

Even in the CPs that scored above 3, there were still some areas which had low scores, hence, denoting serious non-compliances. For instance, there were problems observed regarding the records and traceability of on-farm manufactured feed where four of the farms did not know the date of supply of ingredients (Table 2). Failure to know the supply dates poses the risk of using the feeds that have by-passed their shelf life. Also there were problems regarding records and traceability for feeding where two of the farms did not feed the fish in ponds and tanks according to pond or batch identity codes and feeding was not linked to time and date. This also poses challenge of tracing the affected fish in case hazard-contaminated feeds are discovered to have been used.

Compliance of the farms with policy, legal and certification requirements

Apart from two points (registration by the competent authority and environmental and risk assessment), the rest of the requirements under this section - scored below 1.5 (Table 3). The requirements for approval by, and registration with the competent authority scored

Table 2. Compliance of fish farms (n = 10) with international recommendations for traceability and records.

Control points (CP) and control measures (CM)	Number of recommended conditions (RC) for each control measure	Mean scores of control measures (CM)	Minimum Score	Maximum Score	Number farms where CM scored zero	No of farms where CM scored 5
CP9 records and traceability of fish						
CM1.1: Whether there is/are unique identity (batch) codes for all fish	1	3.00	0.00	5.00	2	4
CM1.2: If details of all fish species and their sources are kept	1	1.00	0.00	5.00	8	2
CM1.3: Whether history of transfers both from suppliers and with in ponds/tanks at the facility are documented	1	3.60	0.00	5.00	1	6
CP10 records and traceability of feeds						
CM 2.1 Whether the details and identities and details of suppliers of feed are kept	2	3.1	0.00	5.00	1	1
CM2.2 Whether suppliers' documents (notes) indicate the composition and or/the ingredients of feed	1	3.23	0.00	5.00	1	3
CM 2.3 Whether exiting records show the date of arrival of the feeds at the facility	1	4.45	1.50	5.00	0	8
CP11 record and traceability of on-farm manufactured feeds						
CM4.1: Whether identities of suppliers for all ingredients are known and recorded	1	4.75	3.50	5.00	0	8
CM4.2: Whether the nature and composition of all ingredients for feed manufactured on farm are known	1	4.15	0.00	5.00	1	7
CM4.3: Whether the methods for manufacture and recipe of feed is documented	1	4.40	0.00	5.00	1	8
CM4.4: Whether the date of supply of ingredients and feed manufacture is known	1	2.55	0.00	5.00	4	3
CP12 records of feed and feeding traceability						
CCM5.1: Whether the feeding of fish in ponds/tanks done according to pond/batch identity and if batch feeding is linked to time and date	1	3.50	0.00	5.00	2	6
CP13 fish health records						
CM6.1: Whether fish health records exist at the farm and properly maintained	1	5.00	5.00	5.00	0	10
CCM6.2: Whether fish mortality at the farm are recorded	1	3.90	1.00	5.00	0	6

Table 2. Contd.

CP14 production and marketing records						
CM7.1: Whether all products from the farm recorded by pond/tanks with batch codes, dates of harvest and market destinations	1	4.25	0.00	5.00	1	7

Table 3. Compliance of fish farms (n = 10) with respect to policy, legal and certification requirements.

Control measures (CM)	Number of recommended conditions (RC) for each control measure	Mean scores of control measures (CM)	Minimum Score	Maximum score	Number farms where CM scored zero	No of farms where CM scored 5
CM 1: Whether the farm is approved and registered with competent authority	1	4.50	2.50	5.00	0	7
CM 2: Whether farm has quality and residue monitoring plans, water use permit	3	1.22	0.00	2.67	2	0
CM 3: Whether the farm implements a written environmental policy and whether environmental and food risk assessments were undertaken for the site	3	3.20	2.67	3.33	0	0
CM 4: Whether farm has and implements quality manual	1	0.20	0.00	1.00	8	0
CM 5: Whether farm has and implements a HACCP plan or manual	1	0.00	0.00	0.00	10	0
CM 6: Whether the facility has and implements a fish health management plan	1	0.45	0.00	2.50	0	0

highly (4.5 ± 0.9) with 7 of the farms having full compliance (Table 3). The good performance under this section is attributed to the fish restocking programme that had been implemented by the Uganda's Department of Fisheries Resources (UDFR) which is the competent authority responsible for registration and approval of aquaculture farms in Uganda. Some of the farmers had been given contracts to supply fish fry and fingerlings to other farmers in a government bid to stimulate aquaculture development. Since both the fish fry producers and other farmers had to benefit under the programme, they had applied to UDFR for the support which enabled the compilation of the list of the farmers by UDFR. By the time this evaluation was done, the farms on this list were by default regarded by UDFR as registered and approved. The underlying reason for this was because the staff of UDFR had visited and verified existence of the farms during the implementation of that programme.

The requirement on environmental policy and risk assessment had a fair compliance with a score of 3.2 ± 0.3 for the same reason. However, registration and approval of farms should be more than just visiting and verifying their existence. The results of inspections should be included to certify that farms are operating in accordance to regulatory guidelines. All the farms did not implement a written HACCP plan, eight of them did not implement a written quality manual, and two of them did not implement a written quality and residue monitoring plan for pond water. All the 10 farms did not have a water use permit from the competent agency as well. Although HACCP implementation is not yet a regulatory requirement for aquaculture, it has been recommended as a tool for eliminating or reducing food safety hazards in farm operations (EC Reg. 852/2004; WHO, 1999). Therefore, the failure to implement HACCP would imply that aquaculture operators cannot assure the safety of their aquaculture products to the consumers.

Table 4. Compliance of fish farms (n = 10) with respect to implementation of written standard sanitation operating procedures.

Control measure (CMs)	Number of recommended conditions (RC) for each control measure	Mean scores of control measures (CM)	Minimum score	Maximum score	Number farms where CM scored zero	No of farms where CM scored 5
CM 1: Whether there are water quality and waste management procedures	2	0.10	0.00	1.00	9	0
CM 2: Whether there are written procedures for control of specific known hazards	1	0.10	0.00	1.00	9	0
CM 3: If there are documented pest and predator control procedures	1	2.35	1.00	3.50	0	0
CM 4: Whether there are specific instructions and procedures for traceability	1	1.85	0.00	5.00	4	1
CM 5: Whether there is are written crises management and product recall procedures	1	0.00	0.00	0.00	10	0

The low score obtained for implementation of water quality and residue monitoring plans and the failure to obtain a water use permit implies that farmers do not particularly know (or may be do not care) about the quality of the water they use for aquaculture which may compromise the safety of their products. Farmers should determine the quality of aquaculture water before raising the fish. In addition, farmers should keep a log for monitoring the quality of aquaculture water. These conditions are necessary to produce safe products. A permit from the competent agency for water use could provide some level of assurance that the water permitted to grow fish is safe.

Compliance of farms with requirements for written standard sanitation operating procedures

The majority of farms scored zero for most of the on-farm SSOPs evaluated (Table 4). All farms (10) did not have written and were not implementing crisis management and recall procedures, nine farms did not have water quality and waste management procedures, nine farms did not have written procedures to prevent or control specific food hazards at the farm and four farms did not implement any traceability procedures.

Written SSOPs is an essential requirement for GAqPs. The failure by the farms to implement SSOPs for farm practices is an indicator that farmers were not implementing GAqPs which are essential to enhance the safety of their products. GAqPs normally eliminate/or reduce greater portion of possible hazards during primary production stage and are a pre-requisite for HACCP implementation (Koonse, 2005; Reilly and Käferstein, 1997). The highest score that was obtained was for farm procedures on pest and predator control (2.35 ± 0.7). Even though each of the farms had in place predator control procedures, they were not adequate to control all controllable predators. More so, not all of these procedures were properly documented. Although some of the farmers demonstrated having knowledge required for implementing SSOPs, without adequate documentation, the frequency and accuracy of their implementation is in question. Documenting on-farm SSOPs reduces accidental contamination by farm workers resulting from wrong measurements and/or treatments for feeds, drugs and other inputs. It also reduces the potential of hazards getting introduced in the fish due to the use of wrong protocols. Farmers should be guided in the development of SSOPs and sensitized about the link between these and safety of aquaculture products.

Compliance of the farms with respect to training and skills of aquaculture staff in food safety

The managers of nine out of ten farms had the necessary training and skills in managing aquaculture operations. In four of the farms, the managers had obtained the aquaculture knowledge and skills as part of their diploma and/or degree education. The managers in the rest of the farms (five) received aquaculture training and skills through short courses and study tours organized by government agencies. However, a low average compliance score of 1.2/5 [24% complaince] was obtained for food safety training and skills of farm workers/managers during the evaluation of farms against the international recommendations. Two of the farms scored zero on this requirement, meaning that the fish farms were hiring staff that lacked the required knowledge and skills for

Table 5. Overall scores of thematic areas used in the evaluation of compliance of aquaculture chain in Uganda against international guideline.

Serial number	Thematic area	Number of control points (CP)	Overall average score for thematic area	Number of CPs where average score < 2	Percentage of CPs where average score < 2	Number of CPs where average score > 4
1	Potential critical control points	7	2.71	0	0	1
2	Traceability and records	6	3.71	0	0	2
3	Policy, legal and certification requirements	6	1.60	4	80	1
4	Use of written SSOPs	5	0.88	4	100	0
5	Training of farm workers	1	1.20	1	100	0

production of safe products. This would imply that farm managers and staff of such farms did not have any knowledge and skills to properly design and implement the necessary SSOPs, GAqPs, and HACCP. In such a scenario, it would be difficult for farmers to assure their buyers and consumers that the products they produce are safe. There is need for training of aquaculture farm staff on food safety issues and food safety control measures, which should be achievable in Uganda given the general basic knowledge and skills already possessed by the farm workers.

General compliance of aquaculture chain

The overall average score of all the elements used in evaluation was lower for the thematic area of use and implementation of SSOPs; followed by training and skills of farm workers; policy legal and certification requirements and; potential critical control points in that order. The best performance was realised by the thematic area of traceability and records (Table 5). Similarly, the numbers and percentages of control points for which average score were below 2 were higher for the thematic area of use of written on-farm SSOPs followed by training and skills of farm workers; policy, legal and certification requirements; and potential critical control points; with the traceability and records also realising better performance. The findings could imply that the aquaculture farms in Uganda were largely not implementing written SSOPs, an indication that they were not applying GAqPs (Garret et al., 1997; Koonse, 2005). The lack of GAqPs implies that sanitation practices which are a pre-requisite for hazard control were being observed, hence, having an immediate negative impact on the safety of the products. SSOPs normally contain protocols for guiding farm operators on the measures to control food hazards, and the lack of them could have contributed greatly to the score of 2.71/5 [or 54% compliance] obtained for thematic area on potential critical control points (Table 5). The poor performance of the thematic area of training and skills of farm managers could have indirectly impacted on the performance of all the other control points within the thematic areas evaluated, simply because of the role played by knowledge and skill in raising the farmer's understanding of food safety and making decisions on the interventions necessary to achieving product safety. This explains the low overall score for all the thematic areas (when all the farms are considered) of 2.02/5 [or 40.4% compliance].

The poor performance of thematic area of policy, legal and certification requirements is attributed to the fact that the aquaculture controls in Uganda had just been introduced, with farmers having not yet acquired the necessary knowledge due to the weak regulatory services (Bagumire et al., 2009b). The aquaculture operations performed well in the area of traceability and records mainly because the existing legislation [UDFR/MAAIF, 2006; Uganda, Fish (Aquaculture) Rules 2003] has a requirement for farms to take records, but also the extension services in Uganda have in the past promoted record keeping though not necessarily for food safety purposes, but as a business practice for taking stock to understand the performance of the farms. The low average score for food hazard control measures at potential critical control points in the aquaculture chain of 2.71/5 (or 54% compliance) (Table 5) indicates that there were significant chances for hazards to contaminate aquaculture products in the production chain and the poor performance of the entire aquaculture chain (score = 2.02 or 40.4% compliance) would imply that Ugandan fish farms still face major challenges to meeting requirements for prime international markets.

Conclusion

Deficiencies in food safety control measures were observed in a significant number of control points used in the evaluation of aquaculture farming in Uganda. Storage and processing practices were potentially likely to introduce food hazards in the feed. Majority of the farms did not observe the traceability requirements of keeping records on history, movements and treatments for fish in the ponds. Also, the observed failure to implement written

SSOPs means the farms were not implementing GAqPs for which they are a pre-requisite.

Deficient practices as observed in this study can lead products from Uganda and other sub-Saharan countries with similar production conditions being denied access to better markets. Because major markets for fishery products like the EU enforce food safety control measures covering entire value chain from farm to table. The fact that veterinary drug use was not an issue is particularly an advantage in the export trade for Uganda and very likely other countries in sub-Saharan region with similar production conditions, because their residues are frequently looked for in shipments by importers. However, this should be regarded as a temporary situation since as the aquaculture industry develops, more intensively stocked aquaculture systems will be utilised hence increasing the risk of infection of fish with pathogens and parasites and therefore requiring use of veterinary drugs and antibiotics. When this happens, a future review would be needed to determine the impact of farm practices regarding the control of risks from aquaculture drugs.

It should also be noted that the non-compliances observed in this study may not necessarily mean that food from Uganda's aquaculture is currently unsafe, since the deficiencies mainly occurred in areas that do not immediately change the safety status of the product; but could rather have incremental effect on safety over a long period of time, when not rectified. Therefore, a number of practical interventions to control the hazards in aquaculture which ensure that the practices result in safe food are needed for Uganda and other sub-Saharan Countries aiming to access prime markets in industrialized countries. The competent authorities (CAs) in these countries should adopt measures recommended in target markets and incorporate them in their national legislations. Manuals for monitoring and control of aquaculture facilities, practices and products should be based on the requirements of the legislations.

Further studies aimed at understanding the "home-grown" measures and practices that provide equivalent protection to consumers as those recommended for international markets, but which are affordable to small scale farmers in sub-Saharan Africa that do not have access to human and financial resources of undergoing rigors of advanced programmes like HACCP are needed. More so, innovations should be advanced in the existing extension services to incorporate food safety messages targeting small scale farmers that place fish products on market.

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