Aquacultural Engineering 49 (2012) 35–45

Contents lists available at SciVerse ScienceDirect

Aquacultural Engineering

journal homepage: www.elsevier.com/locate/aqua-online

Aquaculture Farm Food Safety and Diseases Risk Assessment (AquaFRAM): Development of a spreadsheet tool for salmon farms

J.M. Soon[a,b,*], R.N. Baines[a,1]

[a] School of Agriculture, Royal Agricultural College, Cirencester, Gloucestershire GL7 6JS, UK
[b] Department of Agro Industry, Faculty of Agro Industry and Natural Resources, Universiti Malaysia Kelantan, 17600 Jeli, Kelantan, Malaysia

ARTICLE INFO

Article history:
Received 14 November 2011
Accepted 19 February 2012

Keywords:
Atlantic salmon
Biosecurity
Food safety
Good Aquacultural Practices
Likelihood
Qualitative risk assessment

ABSTRACT

Atlantic salmon (*Salmo salar*) is the most significant aquaculture species in Europe, both in terms of production and economic value, with Norway, followed by Scotland and Ireland as the three major European producers. The objective of the present study was to develop a spreadsheet tool for aquaculture farm-food safety and diseases risk assessment (AquaFRAM) for salmon farms in the UK, (and possibly more widely) to encourage farms to assess potential hazards and diseases. AquaFRAM functions primarily as a self-assessment risk ranking and risk-learning tool to determine the potential of farm food safety hazards, diseases and the level of possible risk for contamination and infections. AquaFRAM has been developed using MS Excel software utilising a qualitative risk assessment approach for farmers to evaluate their food safety practices and diseases on their farms. The risk assessment is based on the risk matrix of frequency of likelihood × severity, where the farmers can judge the likelihood of the hazards occurring on their farm based on given examples or scenarios. Grounding of the model, based on severity scoring is predicated on relevant reports in the literature and expert opinion derived from a separate Delphi study. The AquaFRAM Tool has since been tested on 9 salmon companies throughout UK. All of the farms which tried and tested the AquaFRAM Tool reported it being farmer-friendly and practical. It was highlighted that the current tool focused mainly on risk reduction and not risk elimination. However, such farm food safety and diseases risk assessment tool would be helpful, and certainly timely, to further encourage farms to assess potential hazards and diseases. It is also appropriate for educational and training of full-time and seasonal farm workers.

1. Introduction

The Atlantic salmon (*Salmo salar*) is the most significant aquaculture species in Europe, both in terms of production and economic value, with Norway, followed by Scotland and Ireland as the three major European producers (FAO, 2006). Salmon is the major seafood product in the UK (154,164 tonnes in 2010) with an estimated retail value of £539.6 million compared to shellfish (7199 tonnes in 2010) worth £6.7 million (Scottish Government, 2012; SSPO, 2009). Potential hazards to food safety by consumption of farmed salmon includes (i) toxic chemicals and chemical compounds which have been accumulated by the fish from their aquatic environment or from their food or as residues from veterinary medicines and (ii) pathogenic organisms in the fish, such as parasites, viruses and bacteria which may be harmful to humans (Fairgrieve and Rust, 2003). Regulation 178/2002 (applicable since 1 January 2005) stated that hazards are "biological, chemical or physical agents in, or condition of, food or feed with the potential to cause an adverse health effec", risk is "a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard" (EC 178/2002). The generic meaning of risk refers to the measurement of risk and the identification of factors that influence it (Voysey and Brown, 2000). The specific (or formalised) meaning of risk assessment is the scientific evaluation of known or potential adverse health effects resulting from human exposure to foodborne hazards (FAO/WHO, 1995). The ultimate goal of risk assessment process is to estimate the probability and severity of risk occurrence using qualitative and/or quantitative information (Coleman and Marks, 1999; Davidson et al., 2006) and subsequently to identify opportunities for intervention (Schlundt, 2000).

The EU Food Hygiene Regulations, enforced since 1 January 2006 extended the food hygiene and safety legislations to primary producers (EU, 2004). Although farmers are currently not required to

* Corresponding author at: School of Agriculture, Royal Agricultural College, Cirencester, Gloucestershire GL7 6JS, UK. Tel.: +44 7500 233538; fax: +44 1285 650219.
E-mail addresses: janmei.soon@yahoo.com, janmei.soon@student.rac.ac.uk (J.M. Soon), richard.baines@rac.ac.uk (R.N. Baines).
[1] Tel.: +44 1285 652531x2255; fax: +44 1285 650219.

0144-8609/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.aquaeng.2012.02.002

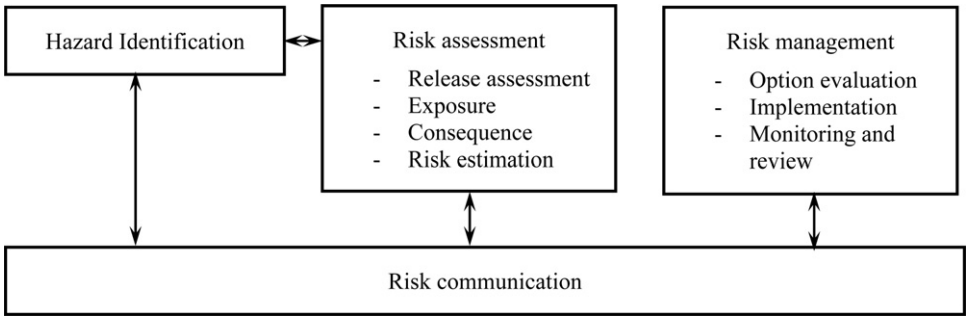

Fig. 1. The Covello–Merkhofer risk analysis model (Covello and Merkhofer, 1993).

implement a hazard analysis critical control point (HACCP) system, they must conduct assessments and follow good hygiene practices in order to control food safety hazards occurring on farms (Food Standards Agency, 2010a). Primary production sectors are required to conduct and show proof of risk assessments being carried out to ensure hazards are identified and controlled. It is important for farmers to identify or recognise sources of microbial and chemical contaminations to reduce or prevent the introduction, survival or growth of pathogens before entering the next stage of the food chain. By reducing risks at the farm level, this will be beneficial to the subsequent stages of the food chain – since the microbial and chemical load are reduced and productivity is increased due to minimal loss from diseased fish. Hence this paper aims to develop a farm food safety and disease risk assessment (AquaFRAM) tool for salmon production.

1.1. Risk ranking tools

There are a number of risk ranking and decision support tools available such as Hygiene Risk Assessment Model (HYGRAM) system for processing (Tuominen et al., 2003), Foodborne Illness Risk Ranking Model (FIRRM) (Batz et al., 2004; FAO/WHO, 2006), Risk Ranger (Ross and Sumner, 2002), CARVER + Shock Tool (FDA, 2010), Stepwise and Interactive Evaluation of Food Safety by an Expert System (SIEFE) tool (van Gerwen et al., 2000) and Import Risk Analysis (IRA) (Covello and Merkhofer, 1993; Peeler et al., 2007). IRA was based on the Covello–Merkhofer risk analysis tool (Fig. 1) and had been used to assess the potential entry routes of *Gyrodactylus salaris* into UK (Peeler and Thrush, 2004) and introduction of viral heamorrhagic septicaemia (VHS), infectious haematopoeitic necrosis (IHN) and *G. salaris* via fish transporters (e.g. lorry) (Peeler and Thrush, 2009). Based on similar principles, AquaFRAM assessed the likelihood of food safety hazards and diseases at the farm level.

2. Methodology

2.1. User interface

The model was developed in Microsoft® Excel spreadsheet software using standard mathematical and logical functions. The "Check Box", "Option Button" and "List Box" macro tools available on the "Forms Control" toolbar under the Developer menu were used to automate the conversion from qualitative inputs to quantities for use in risk scoring. The macro tools allow users to select from the options by clicking on their choices (Ross and Sumner, 2002). The software then converts the qualitative example into

Table 1
Potential food safety hazards and diseases during salmon aquaculture production.

Hazards/diseases	References
Biological	
Salmonella sp. (in fish feed)	Lunestad et al. (2007), Møretrø et al. (2003)
	Risk of *Salmonella* in fish feed being passed on to consumer is negligible (Nesse et al., 2005)
Listeria monocytogenes	
Smoked salmon	Jørgensen and Huss (1998), Lappi et al. (2004), Lindqvist and Westöö (2000)
Marinated salmon	Midelet-Bourdin et al. (2010)
Parasites – *Anisakis simplex*	Marty (2008)
Chemical	
Polychlorinated biphenyls	Easton et al. (2002), Hites et al. (2004), Pinto et al. (2008)
Dioxins	Jacobs et al. (2002)
Polybrominated di-phenyl ethers	Hayward et al. (2007), Shaw et al. (2008)
DDT	Svendsen et al. (2007), Usydus et al. (2009)
Endosulfan	Easton et al. (2002)
Heavy metals (methyl-mercury, cadmium, lead, arsenic)	Hightower and Moore (2003), Mahaffey et al. (2004), Mergler et al. (2007), NIFES (2010)
Veterinary residues	Akinbowale et al. (2006), Miranda and Rojas (2007), Reeves (2007)
Physical	
Metal pieces (e.g. injection needles for vaccination)	Kleter et al. (2009)
Diseases	Stead and Laird (2002), Bruno and Poppe (1996)
Bacterial Kidney Disease	
Enteric Redmouth Disease (ERM, *Yersinia ruckeri*)	Tobback et al. (2007)
Infectious Salmon Anaemia (ISA)	
Infectious Pancreatic Necrosis (IPN)	
Viral Haemorrhagic Septicaemia (VHS)	
Furunculosis	
Fungal infection (*Saprolegnia* spp.) in eggs	
Pancreas disease	