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ROSEANNA AVENTO AND ATTE VON WRIGHT

From Farm to Fork

A Guide to Finnish Food Safety and Quality Management

FROM FARM TO FORK:

A GUIDE TO FINNISH FOOD SAFETY AND QUALITY MANAGEMENT

Roseanna Avento and Atte von Wright

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ABSTRACT

This guide is an overview of the Finnish food safety and quality management system from farm to fork. It provides an introduction to EU legislation that defines the legal foundation for operations in the food sector. We give an introduction to microbiological and chemical safety and explain, how the Finnish authorities work in concert with different stakeholders in the sector to ensure a system that guarantees the high quality and safety of food on the market, causing no harm to human health.

The guide illustrates how food safety and quality are managed using three case examples of the value chains for (i) dairy and beef, (ii) fish and (iii) berry production, respectively. The principles of the hazard analysis and critical control points (HACCP) concept and food safety standards like ISO 22000:2018 are also explained. We discuss the role of different actors in the food chain from farmers and processors to individual workers, emphasizing the role of education in managing food safety and quality.

The practices described in this guide cannot be duplicated directly in countries with different legal and educational frameworks, but we recommend a creative approach to adopting and applying some of the elements in different geographic and economic contexts. The aim is to share good practices to inspire and encourage food sector experts to create their own innovative solutions to ensure access to safe, healthy and nutritious foods.

Keywords*: Food Safety, Food Quality, HACCP, ISO 22000, Food Value Chain*

Foreward

The ancient Silk Road has marked Central Asia for centuries. Trade and productive capacities within the agricultural sector remain at the forefront within the region. Distances are now shorter than ever and production is inter-dependent. The application of strong quality standards is vital to ensuring that agricultural and production sectors remain competitive.

The United Nations Development Programme jointly with the University of Eastern Finland and the kind support of the Government of Finland are supporting countries within the region to apply internationally recognised quality standards.

With the Kyrgyz Republic as a focus, the Aid for Trade project encouraged links between knowledge institutions in the Kyrgyz Republic and in Finland to address quality and safety management within the food sector. A series of training courses and exchange visits took place in the Kyrgyz Republic and Finland.

This guide presents in a simple, straightforward fashion, experiences from Finland during the exchanges between the two countries and highlights best practices, based on EU legislation, to ensure safe and good-quality food. The content is based on training conducted by the University of Eastern Finland for Kyrgyz food sector stakeholders and on issues based on their special interests. The information presented in this guide is also applicable to other Central Asian countries and other regions of the world.

1st September 2020

Juha Virtanen
Ambassador
Senior Advisor
Ministry for Foreign Affairs
of Finland

George Bouma
Sustainable Development Team
Leader
Istanbul Regional Hub
United Nations Development
Programme

The Aid for Trade project works to promote inclusive growth through the promotion of green productive capacities and competitiveness. The strategy is designed to provide support to building productive and export capacities for niche products, identified in the agricultural, agro-industrial and other employment-rich and potentially "green" sectors, to contribute to more economically, socially and environmentally sustainable growth patterns. The project is funded by the Government of Finland.

Acknowledgements

This guide is a product of a long collaboration between food sector stakeholders in Central Asia and the University of Eastern Finland. We have had the privilege of working with many different people and organisations in the Kyrgyz Republic and in Kazakhstan on different aspects of food security, for a decade. In our interactions, food safety and quality management have always been central points of discussion. It was therefore, without hesitation, that we took up the task of working more closely with food sector stakeholders in the Kyrgyz Republic to address the challenges in food safety and quality management that they face.

We consulted Kyrgyz food companies in their processes and delivered training in Bishkek and Kuopio, to Kyrgyz food sector stakeholders. This guide is one of the outcomes of the project, aiming at sharing experiences that can be adapted to different geographical, cultural and enterprise contexts. We hope that this publication will be useful for, not only Kyrgyz food sector actors, but also more widely in Central Asia and perhaps globally, as well. The concepts presented here are universal, although the regulatory environment might differ from country to country.

We thank the United Nations Development Programme and the Ministry for Foreign Affairs of Finland for the opportunity and funding that enabled the delivery of training and the compilation of this guide. Furthermore, we would especially like to thank Ms Daniele Gelz and Mr Urmat Takirov for their support through this process. In addition, the help of Ms Ibarat Kurbanova for all the practical arrangements and facilitation during the trainings delivered is gratefully remembered. Thanks are also due to Ms Burul Nazarmatova for her enduring support.

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Most of all we thank all those food sector stakeholders in the Kyrgyz Republic with whom we interacted. We hope that this guide will prove to be a useful tool for all of you and others globally, and wish you success in ensuring safe and quality food for the communities you serve.

Kuopio, 1st September 2020

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1 Introduction

By 2050, the world will have to feed 9 billion people. The United Nations (UN), in its Sustainable Development Goals (SDGs), has committed to enhancing food security and attaining zero hunger (SDG Number 2). Food security is defined as when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their food preferences and dietary needs for an active and healthy life. Sustainable food production is therefore tied to ensuring maximum gains to public health, which is central to SDG Number 3 'Good health and well-being'.

Quality is an important factor to be considered when discussing food security. Quality involves all the attributes and characteristics expected by the consumer from the product and essentially implies that a product with excellent quality meets the highest expectations of the consumer. When it comes to food, these attributes include availability, constancy, price, nutritional properties, sensory properties and, most importantly, safety.

Food safety is an integral part of achieving food security. If food is not safe, people cannot lead an active and healthy life. Therefore, countries must safeguard their food value chains from hazardous microbes, chemical contaminants and foreign substances that can disrupt the health of their citizens.

The European Union (EU) is committed to implementing the SDGs and has integrated these into EU policies and legislation. According to the European Barometer 2019[1], the most important factors for Europeans when buying food are the source of food (53%), cost (51%), food safety (50%) and taste (49%). The EU's food safety policy aims to protect consumers while guaranteeing the smooth operation of the single market. To this end, legislation has been developed to ensure food hygiene as well as animal health and welfare, and to control contamination by external substances.

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[1] European Food Safety Authority, 2019. Eurobarometer on Food Safety in the EU 2019

There are many factors that affect food safety and the quality of food. On average, every fifth European consumer is concerned about food safety. The top concerns are antibiotic levels in food, hormones and steroids in meat, pesticides, environmental pollutants and food additives. Bacterial contamination is, however, the biggest risk factor leading to problems in food safety.

Globally, every tenth person faces foodborne disease, the most common causes being infections from *Campylobacter* spp. and *Salmonella* spp. bacteria[2]. Foodborne diseases impose a high burden on low and middle-income countries in particular, emphasising the fundamental role of food safety in achieving the SDGs.

In Finland, food safety and quality are, overall, in excellent shape and there is little concern for antibiotic residues in foods, because antibiotics are only used in animal production for treatment purposes and not as growth promoters. There are also very strict regulations on observation of withdrawal periods. In addition, herbicide- and pesticide-residue levels are among the lowest in Europe.

An increasing global population, climate change and food waste have disrupted food value chains and the management of food safety. In addition, new food trends at the consumer level, such as the use of insects in food products, vegetarian diets and organic foods, bring forth new dimensions in safety and risk assessments. For example, allergens and possible pesticide residues in insect-based foods must be assessed. Organic foods are also not necessarily a guarantee of safety. For instance, organic rice has as much arsenic as conventional rice, and the processing of organic foods produces as much acrylamides as other food products do.

SDG Number 6: ‘Clean water and sanitation’ is also central to food safety. About 80–90% of all water used globally is used in the production and processing of food[3]. The availability of safe and sufficient water supplies is inextricably linked to wastewater management. The UN estimates that 80% of wastewater flows back into the ecosystem without being treated or reused, contributing to a situation where

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[2] World Health Organisation, 2015. WHO Estimates of the Global Burden of Foodborne Diseases

[3] UNESCO, 2017. The United Nations World Water Development Report, Wastewater: The Untapped Resource

around 1.8 billion people use faecally-contaminated drinking and household water, exposing them to the risk of contracting cholera, dysentery, typhoid and polio[3]. It is therefore important to ensure that groundwater and surface waters are kept unpolluted by agricultural processes, and that the water used in food processes is potable so that the risk of pathogen exposure is reduced.

Risk management in food safety requires, above all, a recognition of the hazards and how to control them. The United Nation's Food and Agriculture Organization (FAO) and the World Health Organization (WHO) have issued a call to action[4] to keep food safe through five steps:

- Ensure it is safe – governments must ensure safe and nutritious food for all
- Grow it safe – agriculture and food producers need to adopt good practices
- Keep it safe – business operators must make sure food is safe
- Eat it safe – all consumers have a right to safe, healthy and nutritious food
- Team up for safety – food safety is a shared responsibility

An effective food safety management system is therefore important in order to minimise food-associated risks, and is an integral part of a total quality management system. Managing food safety and quality also implies that traceability is well managed and promotes preparedness for food safety emergencies, which is globally more important now than ever.

This guide introduces the Finnish approach to managing food safety and quality, focusing on the blocks of legislation, and understanding the microbial and chemical risks to food safety and hygiene management. Furthermore, we introduce managing food safety using the hazard analysis and critical control points (HACCP) principle of the *Codex Alimentarius* and different food safety management systems. We discuss an important part of food safety communication through a presentation of the food safety labelling system in the EU. We also discuss how food safety and quality are managed along food value chains by demonstrating the shared responsibility of producers, processors, food handlers, food businesses and the authorities. Finally, we discuss the role of educating the different actors along the food value chain.

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[4] FAO, 2019. World Food Safety Day 2019. Call to Action

While we recognise that the Finnish approach cannot be duplicated as such, there are elements that could be adopted and applied to different geographical and economic contexts in a creative way. This guide is designed to share experiences and good practices to inspire and encourage food sector experts to create their own innovative ways to ensure that consumers, wherever they are, have can access to safe, healthy and nutritious food. Food safety and quality, after all, is our shared global responsibility.

2 The European Union and its policy on food safety

In the European Union (EU) countries – Finland included – the laws and regulations on food safety are highly harmonized. Foods imported from third countries are generally expected to conform to EU criteria. Importers should pay specific attention to:

- Subscribing to the Hazard Analysis Critical Control Point (HACCP) principles
- The microbiological/toxicological/analytical breakpoints given in the relevant EU regulations (including the testing method/standard, when it is indicated)
- Not forgetting the specific requirements for food contact materials, especially for food contact plastics

2.1 What is the European Union?

The European Union is a federation of member states (Figure 1) that have agreed to submit part of their sovereignty to the Union in order to ensure the free movement of people, goods, and capital. The EU is thus a free-market zone, which also coordinates the trade agreements with external countries.

Currently the EU has a population of approximately 447 million[5] in 27 member states, 19 of which have a common currency, the euro (€). Legislation on food safety is very much harmonized in the EU, and consequently Finland, as a member state, follows the general European food laws in the implementation of national food safety measures.

[5] Eurostat, 2020. Population and Population Change Statistics in Europe

Figure 1. Political map of the European Union member states

2.2 Decision making in the EU

The main actors are the **European Parliament**, the **Council of the European Union**, and the **European Commission** (hereafter the Parliament, the Council, and the Commission). They are located in Brussels, Belgium, with the Parliament also convening in Strasbourg, France, and Luxembourg.

The Parliament passes European laws together with the Council. Its members are elected every five years, and they do not represent their respective countries but are grouped according to their political parties and ideologies.

In the Council, the ministers of the member states share the legislative powers together with the Parliament, and also decide on the economic and foreign policy of the EU. The EU budget is decided jointly by the Council and the Parliament.

The Commission has executive powers, being a kind of 'European Government'. It consists of 26 commissioners, one from every member state. Again, the commissioners are not expected to represent their respective home countries, but only the interests of the Union. Only the Commission has the right to propose new EU legislation. The current President of the Commission is **Ursula von der Leyen**.

The Commission has several departments or 'Directorates General' (DG). The most important DG in matters related to food and food safety is the DG for Health and Food Safety (SANTE).

A central actor with no legislative or executive powers is the **European Council** (not to be confused with the Council of the European Union). The European Council consists of the heads of the states or governments of the member states, and it convenes two to four times per year to decide on the political direction and priorities of the EU. Its current president is the former Belgian prime minister **Charles Michel.**

2.3 The legal instruments of the EU

The two main types of union-wide legal documents in the EU are Directives and Regulations. They differ mainly in the way they are implemented and integrated into the legislation of each member state. The legislative measures defined in the Directives have to be incorporated into their national legislation within two years of the adoption of the Directive and can be adopted as changes or extensions to preexisting national laws. Regulations, however, are automatically in force in all member states immediately after their promulgation. The general trend in the EU is to increasingly replace former Directives with Regulations.

2.4 Food safety legislation in the EU

Because of emerging food safety concerns in the EU, the White Paper on Food Safety, which defines the legislative goals of the EU, was published in 2000. As a policy measure, a thorough harmonization of the food safety regulations within the EU and the establishment of the European Food Safety Authority (EFSA) to perform independent risk assessment in matters related to food and feed were defined as immediate objectives.

The traceability and transparency of the food chain ‘from farm to fork’ was one of the leading principles in the harmonization effort. Accordingly, in 2002, Regulation (EC) No 178/2002 setting out the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety, was published. One important principle was the assignment of the responsibility of food and feed safety to food and feed operators.

In the following paragraphs, the main Regulations that were subsequently introduced are briefly outlined. The published texts of Directives and Regulations in all the official languages of the EU can be easily accessed from eur-lex.europa.eu, and anyone wishing to obtain more detailed information of the content of the regulatory documents listed below is advised to consult this website.

2.4.1 The hygiene package

Three regulations from 2004 (‘the hygiene package’) outline the hygienic requirements of foodstuffs in the EU:

- Regulation (EC) No 852/2004 on the hygiene of foodstuffs
- Regulation (EC) No 853/2004, laying down specific hygiene rules for foods of animal origin
- Regulation (EC) No 854/2004, laying down specific rules related to official controls on products of animal origin intended for human consumption

The aim of Regulation (EC) No 852/2004 is to ensure the hygienic quality of foods in all phases of production, from primary production to delivery to the consumer. An important requirement defined in Annexes I and II of the Regulation is the requirement for sufficient training in hygiene for all persons involved in food-related processes.

While the Regulation lists the requirements for food operators and food establishments in a general way, there are certain specific and detailed requirements that should be mentioned here. For example, Article 5 specifically requires that the food business operators will put in place, implement and maintain the Hazard Analysis Critical Control Point (HACCP) principles, and Article 10 states that imported foods shall comply with EU food law.

Regulation (EC) 853/2004 deals with the specific requirements for foods of animal origin. Establishments involved in food production must be approved and registered by a competent authority of the respective member state (Article 4). Besides the general provisions, the regulation gives detailed instructions on the handling of foods and product-specific requirements, including fresh meat, live bivalve molluscs, fishery products and dairy products (Annex III). The general emphasis of the Regulation is on the traceability and proper handling of foods.

Regulation (EC) No 854/2004, while emphasizing the primary responsibility of the food operator for the safety of food, lays down specific rules related to official controls on products of animal origin intended for human consumption. Specific requirements for the inspection of fresh meat, live bivalve molluscs, fishery products and dairy products are given in Annexes II, III and IV of the regulation, respectively.

2.4.1.1 The HACCP principles

The EU legislation emphasizes the primary responsibility of food operators on food safety. This means that the operators must have a self-monitoring plan, and that the Hazard Analysis Critical Control Point (HACCP)-principles are an integral part of such a plan.

HACCP is a procedure that allows the food operator to control the microbiological or chemical risks in the process. The hazard analysis (HA) involves the identification of potential hazards in the process to establish relevant controls at correct points (CCPs). HACCP is considered a fundamental part of the self-monitoring plan that each food operator should comply with.

HACCP starts by outlining a flow chart of the production process, and by identifying the places (control points) at which control measures are necessary. This identification is the first of the seven steps of HACCP (Figure 2), the other six being:

- The determination of control limits for each control point. A control limit could be the total number of bacteria, a certain critical pH, or any other measurable value of a parameter that is critical to the process or food safety.
- The identification of monitoring procedures (who is responsible, how often, which methodology, etc.)
- The establishment of corrective action procedures, i.e. the actions to be taken if the critical limits are exceeded.
- Establishment of record-keeping and related responsibilities.
- Verification or validation of the HACCP plan.

The principles of HACCP are outlined in the *Codex Alimentarius* (Food Code) which is a collection of recognized standards, codes of practices, guidelines and other recommendations relating to foods, food production and food safety. The *Codex Alimentarius* Commission (CAC) is a joint effort of the United Nation’s Food and Agriculture Organization (FAO) and the World Health Organization (WHO) that was established to protect consumer health and promote fair practices in food trade. All EU countries are members of CAC, hence HACCP has been adopted into EU legislation. *Codex Alimentarius* is recognized by the World Trade Organization (WTO) as an international reference point for the resolution of disputes concerning food safety and consumer protection.

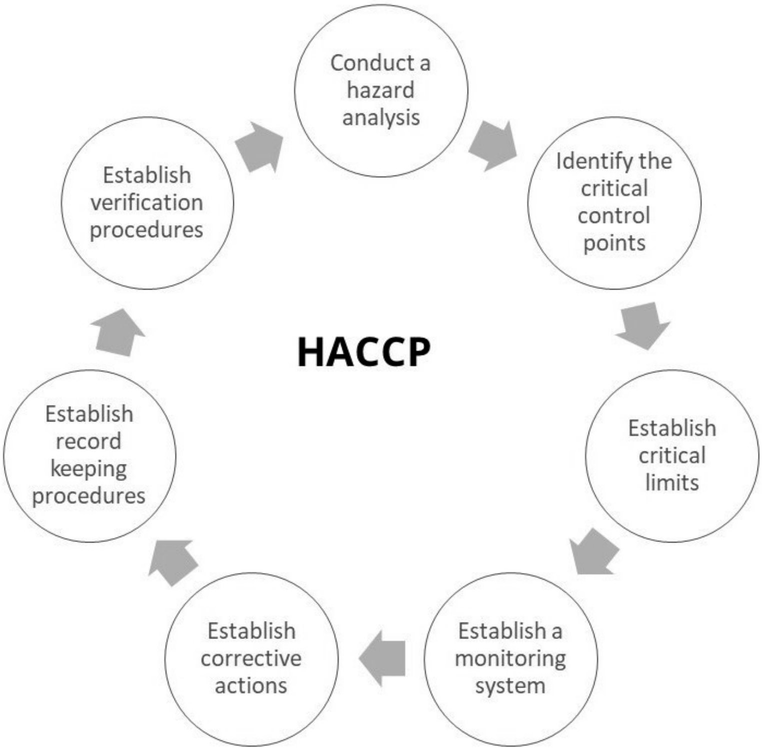

Figure 2. The HACCP principles

2.4.1.2 The microbiological criteria for foodstuffs

Microbial quality is of the greatest importance for food safety, and microbiological examinations of foods form a major part of both in-house and official quality control. Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs harmonises the performance of such examinations and the interpretation of their results.

In Annex I of the regulation, microbiological quality criteria are defined for meat and products thereof, milk and dairy products, egg products, fishery products, vegetables, fruits and products thereof. As an example, for minced meat the following microbiological criteria have been defined as in Table 1.

Table 1. Microbiological criteria for minced meat

Food category	Microorganisms	Sampling Plan		Limits		Analytical reference method	Stage at which the criterion applies	Action in case of unsatisfactory results
		n	c	m	M			
2.1.6 Minced meat	Aerobic colony count	5	2	5×10^5 cfu/g	5×10^6 cfu/g	ISO 4833	End of manufacturing process	Improvements in production in hygiene and improvements in selection and/or origin of raw materials
	E.coli	5	2	50 cfu/g	500 cfu/g	ISO 16649-1 or 2	End of manufacturing process	Improvements in production in hygiene and improvements in selection and/or origin of raw materials

The meaning of the symbols used in the table is as follows:

- cfu/g= number of 'colony forming units' per g of sample
- n = number of samples that should be taken from the lot of food
- m = the lower microbiological limit
- M = the higher microbiological limit
- c = the number of samples that are allowed to have cfu values of between m and M

Thus, out of five minced meat samples, two could have values that are higher than 5 x 10^5 cfu/g (total aerobic bacteria) or 50 cfu/g (*E. coli*), but none is allowed to exceed 5 x 10^6 cfu/g for aerobic bacteria or 500 cfu/g for *E. coli.*

2.4.2 Foreign substances

Foreign substances are not intentionally added to foods. They include residues of veterinary drugs, pesticide residues, harmful compounds of biological origin or environmental contaminants. The main EU regulations dealing with foreign substances are:

- Regulation (EC) No 1881/2006, setting maximum levels of certain contaminants in foodstuffs.
- Regulation (EC) No 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC.
- Regulation (EU) No 37/2010 on pharmacologically active substances and their classification regarding maximum residue limits in foodstuffs of animal origin.

Among the contaminants, the maximum levels of which are listed in Regulation (EC) No 1881/2006, are mycotoxins, nitrate, heavy metals, dioxins and polycyclic aromatic hydrocarbons, melamine, erucic acid and tropane alkaloids.

Regulation (EC) No 396/2005 defines the maximum residue limits (MRLs) for pesticides in plant and animal products used as food or feed. For compounds, for which a toxicological MRL has not been defined, the MRL that is applied is 0.01 mg/kg. The list of MRLs is being compiled, and the most recent values can be found on the Commission's website: https://bit.ly/2Ew3add

Regulation (EU) No 37/2010 covers pharmacologically active substances and their classification in foodstuffs of animal origin. For each substance, the MRL is defined by considering both the toxicological and analytical aspects.

2.4.3 Food contact materials

Food contact materials also need to be safe. Specific EU regulations exist for cellophane and ceramics, but most importantly for food contact plastics. For paper and board, different unofficial industrial and national guidelines exist. Regulation (EU) No 10/2011 on plastic materials and articles intended to come into contact with food is the central document. The regulation:

- Defines and lists the authorised chemicals that can be used in the manufacture of food contact plastics (EU list of authorised substances, Annex I)
- Defines the general migration limits for food, and in cases where there is some toxicological concern related to specific migration limits (SMLs)
- Defines the food simulants and test conditions to be used for migration testing

A general limit for the overall migration of plastic materials into foods/food simulants is 10 mg of total constituents per dm^2 of food contact surface. In the case of foods intended for infants or young children, however, the limit is 60 mg of total constituents per kg food/food simulant (Article 12).

2.4.3.1 Food contact plastics: What must a food manufacturer know?

The testing and determination of overall and specific migration is usually the responsibility of the plastic producers and/or the manufacturer of plastic articles (containers, films, etc.). A food producer must ask for, and the plastic material/article provider must produce, a **Certificate of Compliance** demonstrating that the general or specific migration limits are not expected to be exceeded in the intended conditions (type of food, temperature, contact time) of food contact.

2.5 The role of the European Food Safety Authority (EFSA)

The EFSA was established in 2002 to conduct an independent risk assessment in matters related to food and feed. It is situated in Parma, Italy. The risk assessment is done by scientific panels consisting of known experts in the specific aspects of food and feed safety. The activities of EFSA and its scientific panels are presented on the EFSA website at https://www.efsa.europa.eu/ and in Table 2.

The EFSA is required by European law to carry out risk assessments on regulated products such as genetically modified foods, food and feed additives, novel foods, etc. In addition, it is consulted by the Commission in all questions that might arise regarding food and feed safety. The guidance documents and evaluations published by the EFSA on specific aspects of food safety are, despite not being legal documents, binding on the food and feed sector in practice and are examples of 'soft law' that should be taken into account by food and feed operators.

Table 2. EFSA scientific committees and panels[6]

Scientific Committee	**Senior scientists with experience of work within scientific bodies covering all disciplines across the EFSA's areas of responsibility**
Panel on Animal Health and Welfare	Experts in veterinary sciences, microbiology, pathology and animal production
Panel on Biological Hazards	Experts in epidemiology, microbiology, pathology and exposure assessment
Panel on Food Contact Materials, Enzymes and Processing Aids	Experts in chemical risk assessment focusing on food enzymes and chemicals used in the production of plastic materials or other food packaging
Panel on Contaminants in the Food Chain	Experts in chemistry, exposure assessment, toxicology, epidemiology and statistics
Panel on Food Additives and Flavourings	Experts in chemical risk assessment and safety assessment of food additives and flavouring substances
Panel on Additives and Products or Substances Used in Animal Feed	Experts in animal nutrition, toxicology, microbiology, exposure assessment and environmental studies
Panel on Genetically Modified Organisms	Experts in food and feed safety assessment, environmental sciences, molecular characterisation and plant science
Panel on Nutrition, Novel Foods and Food Allergens	Experts in nutrition, nutritional epidemiology, human medicine, infant nutrition, paediatrics, dietary exposure assessment, food allergy and intolerance, toxicology and food technology
Panel on Plant Health	Experts in pest risk assessment, plant pathology, epidemiology and ecology
Panel on Plant Protection Products and their Residues	Experts in chemistry, toxicology, ecotoxicology, exposure assessment and environmental sciences

[6] EFSA (2020). European Food Safety Authority Scientific Committees and Panels

3 Food microbiology and hygiene

Microbial contamination is the main cause of food poisonings and food spoilage. Contamination can occur at all phases of the food chain, and while the consequences are generally not fatal for healthy adults, the impact on human health and the economy is significant. The prevention and control of contaminations is generally simple when the properties and growth conditions of the harmful microorganisms are known.

While the general organisation for the control of food hygiene is in the hands of governmental and local authorities, food operators are primarily responsible for the safety of their products. Therefore, it is essential that personnel handling food know the principles of hygiene and are motivated to implement them during food processing. Also, high microbiological quality of raw materials obtained from primary producers should be guaranteed, as well as the storage and processing conditions designed to prevent microbiological growth.

The prevention and control of contaminations is generally simple when the properties and growth conditions of the harmful microorganisms are known. The main things to remember are:

- High quality of raw materials
- Well-trained personnel that are well-acquainted with hygienic practices
- Proper storage and processing facilities (surfaces and machinery that are easy to clean, pest control in storage rooms, prevention of cross contamination)
- Proper handling and processing of perishable foods (cold chain maintenance and proper storage, heat treatments, correct use of preservatives, etc.)

3.1 The general properties of microorganisms

As the name implies, microorganisms are too small to be visible to the naked eye. Otherwise, they share only a few common properties and represent very diverse taxonomical groups of organisms. The main groups are briefly presented in the following sections.

3.1.1 Bacteria

Bacteria have a characteristic cellular structure and do not have a specific **nucleus** in their cells. Their DNA is usually organised as a single large, circular molecule. Because of the lack of nucleus, they are called **prokaryotic** organisms.

The bacterial dimensions are usually only a few μm (1 μm = 1 mm/1000), but despite their small size, they are metabolically very capable and diverse. They are ecologically very important and useful organisms, without which life as we know it would not exist on earth.

The metabolic diversity of bacteria can be seen in their oxygen requirements. Some require oxygen and are called **aerobes**, while to others oxygen can even be poisonous and they get their energy anaerobically. They are, accordingly, called **anaerobes**. A large group of bacteria can utilise oxygen, when it is available, but also grow anaerobically in its absence. They are called **facultative anaerobes**.

It should be remembered that only few bacterial species are pathogenic, i.e. they cause diseases in humans and animals, and the vast majority are harmless or even useful. In a human body, the number of bacteria is approximately ten times higher than the number of human somatic cells, and the bacteria in our intestines and on our skin are essential for our health and well-being. Bacteria are also used in many food processes, for example in the manufacture of fermented food products.

Bacteria do not have a sexual life cycle, and they multiply by cell division. The multiplication time can be very short. In suitable conditions the cell division can occur in 15–20 minutes; bacterial growth is then called **logarithmic** or **exponential**. A special feature of certain bacteria (genus *Bacillus* and *Clostridium*) is their ability to form heat-resistant **endospores**, which tolerate temperatures of up to 100°C.

3.1.2 Yeasts and moulds

Yeasts and moulds differ from bacteria in that they have a cell structure (including a nucleus) that resembles that of animals and plants. They are therefore called **eukaryotic** microorganisms. Their dimensions are several times larger than those of bacteria, and the cells of moulds, or filamentous fungi, can form very long filaments or hyphae. These kinds of filaments can be macroscopically visible, for example as mouldy growth on bread or fruit.

Yeasts, on the other hand, usually occur as single cells. Most yeasts and fungi require oxygen, although many yeasts can also grow anaerobically and produce ethanol and carbon dioxide as metabolic end products. This property is used in baking and brewing processes.

Although many yeasts and fungi have a sexual life cycle, their main function is to introduce genetic diversity. The multiplication by cell division is the main method of reproduction. Both yeasts and moulds can form **spores** as their survival forms, and these spores can make these microbes very difficult to eliminate in places they have infested.

3.1.3 Algae and protozoans

Both algae and protozoans are eukaryotic microorganisms. They are abundant in the environment, but do not normally occur in foods. However, because they can be found in large quantities in water, including drinking and household water and water used in food processes, they can enter the food chain, sometimes with harmful consequences.

Algae (or microalgae) are microscopic, single-celled **photosynthetic** organisms, meaning that they can obtain energy from sunlight. They do not cause diseases as such, but many species produce toxic metabolites that can be harmful for humans and animals, for example via drinking water.

Protozoans are free-living, single-celled, non-photosynthetic microorganisms. As algae they can be found in soils and water, with an ecological role of their own, forming a significant link in the food chain. Some of them are parasitic, causing human and animal diseases, and can spread via drinking water. Giardiasis is a typical water-mediated infection caused by the protozoan *Giardia lamblia*.

3.1.4 Viruses

Viruses do not have independent lives of their own, but they are obligate parasites of animals, plants or bacteria. They multiply by introducing their genetic material (DNA or RNA) into the host cell, reprogramming it to produce new virus particles.

The dimensions of viruses are from tens to hundreds of nanometres, and their basic structure is simple. They basically consist of a nucleocapsid that contains the genetic material. The nucleocapsid also has specific structures that enable the virus to recognise and infect the host cell.

Parasitic viruses cause various human and animal diseases – some of them fatal, some mild. Seasonal influenza epidemics are typical examples, while human immunodeficiency virus, *Ebolaviru*s and *Lassavirus* represent very serious pathogens. Foot and mouth disease is an example of a viral disease affecting domestic animals and causing severe economic losses. While viruses do not multiply in the infected food, virus-contaminated water can cause food poisoning epidemics, exemplified by Norwalk virus or norovirus.

3.2 The general conditions for the growth and survival for microorganisms

Despite the taxonomic diversity of microorganisms, their general growth conditions and requirements for survival are very similar. Most of them prefer the pH range 5–8, although there are examples of microorganisms, particularly bacteria, that grow or at least survive at pH values outside this range.

The preferred temperature range is 15–40 °C, but again there are examples of **psychrophiles** favouring temperatures below 10 °C, and **thermophiles** living at temperatures > 50 °C (some extreme thermophiles even near the boiling point of water). The special case of heat-resistant endospores produced by *Bacilli* and *Clostridia* has already been mentioned in section 3.1.1.

The third limiting factor is the available water or water activity (a_w). The a_w of pure water has been defined as 1.00, that of soft cheese approximately 0.95, and that of salami 0.82. Only very few microorganisms can grow at a_w values < 0.80.

Traditionally, the keeping quality of perishable foods has been ensured by manipulating the pH (fermentation, adding acetic acid or other acids) or temperature (cooling or heating) and by reducing the aw by drying or adding sugar or salt. These methods are still the basis of industrial scale food production. The growth of aerobic microorganisms can be controlled by creating anaerobic conditions (tinned or vacuum packed foods) or oxygen-free modified atmospheres.

3.3 Some food pathogens and spoilage organisms

3.3.1 Bacteria

Among bacteria, the most frequent species associated with food poisonings include *Salmonella enterica*, enterohemorrhagic *Escherichia coli* (EHEC), *Campylobacter jejuni, Staphylococcus aureus, Listeria monocytogenes, Bacillus cereus* and *Clostridium perfringens. Clostridium botulinum* causes rare but extremely serious – often fatal – poisoning. The characteristics of these bacteria and foods where they are found are indicated in Table 3.

Some of these bacteria have special physiological characteristics that make them especially problematic. *Salmonella* can colonise a diseased person for a long period after the symptoms have ceased, and this person can still effectively spread the infection. *Listeria monocytogene*s survives at pH 4, can grow in a refrigerator and tolerates up to 10% salt, and is therefore difficult to control or eliminate by the standard procedures used in food handling and food technology. *Bacilli* and *Clostridia* have thermoresistant endospores, and insufficient heat treatments, especially of ready-made foods, may allow the growth of these bacteria.

By far the most critical factor regarding bacterial growth is temperature. At optimal temperatures (usually 25–37 °C) exponential bacterial growth can lead to very high bacterial densities in a few hours. In theory, a single *Escherichia coli* bacterium could multiply to approximately one million bacteria in less than seven hours.

Many bacteria also have the ability to form **biofilm**, meaning that they attach to surfaces and secrete around them a protective coat of polysaccharides and protein. This makes them more resistant to ordinary washing and to most cleaning and disinfection agents. *Listeria* biofilms are a real problem in many food processing establishments. Even harmless bacteria can cause problems by affecting the appearance, smell and taste of food products. Lactic acid bacteria, which are a normal part of fermented milks or in products like sauerkraut, may cause unpleasant off-flavours when they grow in other types of foods.

3.3.2 Yeasts and moulds

Yeasts do not produce food poisonings, but they can cause off-flavours and gas formation when they grow in juices, jams or fruit purees. Visible mould growth on bread, jams, marmalades and fruit looks unpleasant and also affects the taste. More serious is the tendency of many moulds to produce toxic metabolites, or mycotoxins. They are very seldom present in quantities that are sufficient to cause acute food poisoning, but they may have long-term effects. For example, aflatoxins (produced by *Aspergillus*- and *Penicillium* moulds) are known carcinogens associated with liver cancer. Mycotoxins are usually detected in cereals, beans, nuts and peanuts. As stated in Chapter 2, the EU has set limit values for the most common mycotoxins in foods.

Filamentous fungi have been used for centuries in the production of certain types of foods (for example in Camembert and Roquefort cheese). In these applications the fungi are safe, but the production of mycotoxins can depend on the growth conditions and nutrients available. Thus, a mould that is safe on cheese could form some harmful substance if it grows on bread.

3.3.3 Protozoans

Protozoans do not live and multiply in actual foods, but they may contaminate foods via water. *Giardia* and *Cryptosporidium* species are common causes of intestinal infections. *Giardia* infections can be particularly persistent, sometimes lasting for several weeks.

3.3.4 Viruses

Viruses can be a problem via contaminated water. For example, infected foods that typically spread the Norwalk virus (norovirus) and the hepatitis A-virus are frozen fruit and berries that have been contaminated via polluted water during cultivation or before the deep-freezing step. Seafood is another common source of hepatitis A infection.

Table 3. Selected bacteria, their occurrence in foods and resulting foodborne disease

Species	**Special characteristics**	**Habitat**	**Foods where found**	**Foodborne disease**
Salmonella enterica	A diseased person can be infective for a long period after the symptoms have ceased	Human or animal intestine, polluted water	Water, salads, fruit, dairy foods, meats	1. Enteritis 2. Systemic disease (typhoid fever)
Enterohemorhagic *Escherichia coli* (EHEC)	Causes a dysentery type of disease	Bovine intestine	Dairy product, meats	1) Enteritis (dysentery-like) 2) Sometimes severe secondary diseases (Guillain Barré syndrome)
Campylobacter jejuni		Animal intestine, water	Water, broiler meat, seafood, water	1) Enteritis 2) Guillain Barré syndrome
Listeria monocytogenes	Grows at refrigerator temperatures, tolerates low pH and high salinity	Soil, animal intestines, water	Tubers, vegetables, dairy foods, fish and seafood	1) Enteritis 2) Bacteremia 3) Meningitis 4) Intrauterine infection (abortions, stillbirths)
Staphylococcus aureus	Produces enterotoxins that cause the food poisoning symptoms	Human or animal skin, nose, mucous membranes	Meats, dairy products, cured meats	Headache, vomiting, diarrhea

Species	Special characteristics	Habitat	Foods where found	Foodborne disease
Bacillus cereus	Thermoresistant spores Produces i) enterotoxins or ii) emetic toxin (cereulide)	Soil	Meats, gravies, puddings and starchy foods (rice and flour dishes etc). Foods that have not been properly heat treated	1) Diarrhea, nausea (caused by enterotoxins) 2) Vomiting (caused by cereulide)
Clostridium perfringens	Anaerobic, produces heat resistant spores, produces enterotoxins	Soil, marine sediments	Meats, casseroles, under-sterilized tinned foods	Diarrhea, nausea
Clostridium botulinum	Anaerobic, produces heat-resistant spores, produces extremely potent neurotoxins	Soil, marine sediments	Sausages, canned foods, vacuum packed fish	Paralysis, collapse of the lung functions

3.4 How to prevent food contamination – hygienic practices

The prevention of food-related hazards and risks is a concern for the whole food chain, from primary production to food processing and marketing. Therefore, the transparency and traceability of the food system is of utmost importance. Good farming practices, good manufacturing practices and well-designed self-monitoring plans, together with informed and committed personnel, are key factors in the establishment of the microbiological safety of foods.

3.4.1 The role of primary production

Only high-quality milk, meat, fruit and vegetables should be used in food manufacturing. While meat inspection and control can be carried out during slaughtering, before the meat enters processing, other types of products typically come to the processing plants directly from farms. Thus, the health status of the production animals, conditions during milking and the storage and transportation of milk, for example, should be satisfactory. Likewise, the quality of fruit and vegetables should be guaranteed by minimising soil contamination, fungal or insect infestation, and wilted or rotten items.

While official standards, recommendations and laws form the basis of high-quality primary production, industry can also play an active role in improving the hygienic status of raw materials. In Finland, the dairy industry has established its own hygienic classification of raw milk, which is somewhat stricter than the EU requirements, and farmers are paid more for the milk that fulfils these criteria.

3.4.2 The role of the food processing plant and management

Food processing plant premises should be designed to minimise the possibility of contamination. The reception and storage of raw materials should be arranged so that the quality does not deteriorate before it enters the process. When storage is necessary, the correct temperature and humidity should be ensured and efficient pest control (insects, rodents, birds) should be implemented. Before entering the process, raw materials should be inspected using methodologies (from visual inspection to laboratory studies) relevant to the material.

In the actual processing facilities, surfaces should be accessible and easy to clean. Proper detergent and disinfectants should be selected, considering their efficiency, occupational safety and harmlessness in the food processing environment.

In the design of the production facilities, the separation of the 'clean part' (the actual manufacturing of the products) and the 'dirty part' (reception of raw materials, equipment, etc.) should be clearly indicated, and access from the 'dirty part' to the 'clean part' only occurs after proper precautions (protective clothing, washing/disinfecting hands, etc.). Lavatories, lunch or tea/coffee rooms, and other social facilities used by the personnel should be located so that the hygienic status of the production facilities are not compromised (as well as the comfort of the personnel). Insects, rodents and birds should also not be able to access or remain in the facilities. Furthermore, suitable and sufficient ventilation is necessary to ensure good working conditions, reduction of temperatures, condensation and humidity. See Table 4 for a compilation of factors to consider when designing and constructing food processing facilities.

Table 4. Factors to consider when designing and constructing food processing facilities

Area	Characteristics
Walls	They should be clean, smooth, impervious, non-flaking, durable and capable of being cleaned and disinfected properly.
Floors	They should be clean, durable, non-absorbent, anti-slip, without crevices and capable of being cleaned and disinfected properly.
Windows and doors	They should be able to resist solar heat gain and should have screens to prevent the passage of insects, rodents and birds into the facilities.
Wash basins	These must have a connection to both cold and hot water.
Waste	Waste disposal containers should have proper lids and should be regularly emptied and cleaned. Tight-fitting lids that are foot-operated are preferred and containers should not overflow.

Depending on the nature of the food product, specific treatments to eliminate harmful microorganisms may be applied. These include heat treatments (from pasteurisation to ultra-high-temperature treatments for liquid foods, cooking, frying, canning at 130°C, using preservatives, sugar or salt, drying, smoking, etc.). The efficiency of these procedures should be assessed by proper testing. The testing regime of raw materials and intermediate and final products is an essential part of the HACCP principles.

The HACCP principles (compulsory in Finland and the EU) prescribe the establishment of an HACCP group consisting of those familiar with the process and the inherent hazards. The responsibility of this kind of group in establishing and monitoring hygienic practices is self-evident, although – if possible – a specific safety manager should be nominated. It is, however, understandable that in small companies one person may have multiple roles, which is fine as long as some of these crucial roles are not neglected.

The proper training of personnel is also the responsibility of the management. Personnel should be expected to have a basic understanding of the principles of hygiene. The teaching of the product/process-specific aspects should be properly done before an employee assumes responsibility for their task.

3.4.3 The role of an individual worker

The individual worker is in a key position to ensure the high hygienic quality of the production process. Their first responsibility is to obtain the necessary knowledge of the general hygienic principles, follow the management's instructions regarding both the specific tasks entrusted to them and the instructions related to cleaning, protective clothing, washing, sanitisation and disinfection, and to report any irregularities that they might observe.

Some specific aspects that should be taken into account:

- The laws related to certain specific food-related risks should be followed (for example regular *Salmonella* monitoring – this is actually the responsibility of the management).
- The required protective clothing (specific work clothes and shoes, covering of hair and beard, removal of personal jewellery, etc.)
- Health conditions that might compromise microbiological safety (intestinal problems, open and infected wounds and other skin

problems, respiratory infections, etc. should be reported to the management).

- Personal hygiene and cleanliness (proper washing/disinfection when entering and leaving the facilities, after visiting the toilet, or after taking lunch or coffee break).
- Hygiene training must be undertaken by individual workers to ensure skills and knowledge to produce safe food. In Finland, all food handlers must hold a Hygiene Passport awarded by the Finnish Food Authority. To obtain this passport, a person must pass an examination designed by the Finnish Food Authority. A typical examination takes 45 minutes and consists of 40 questions, and the minimum number of correct answers required to pass the test is 34. Before taking the test, one may also take a course in food hygiene, which are organised by various institutions and organisations. The examination is given by examiners approved by the Finnish Food Authority, and is mainly done in Finnish, Swedish or English. However, by special arrangement it can also be taken in other languages such as Russian.

4 Chemical safety

Besides high microbiological quality, the chemical safety of foods is of prime importance. Food may naturally contain compounds that are harmful in excessive doses to the general population or to some subset of consumers (for example lactose to those who are lactose intolerant or foods that can cause allergy to certain individuals).

The actual foreign substances include food additives, pesticide and veterinary drug residues, chemical and environmental contaminants, toxins of biological origin, and chemicals that have migrated from food contact materials. Food additives are added intentionally for some technological purpose and only after a safety evaluation. The other types of foreign substances are subject to specific EU regulations already discussed in Chapter 2. The efficient control and elimination of harmful substances requires successful collaboration between authorities, farmers and the food industry.

As in the case of microbiological contamination, chemical contamination can also occur at any stage in the food chain, starting from primary production. In the following sections some of the harmful substances, impurities and contaminants that could be present in foods are briefly reviewed.

4.1 Foreign objects

Foreign objects like earth, dirt, pebbles, stones, insects and their constituent parts, metal and glass fragments and so on can accidentally enter the food chain due to improper handling of the raw materials, technical failures and accidents. They can cause both hygienic, organoleptic and health problems unless they are eliminated. Proper selection and careful inspection of raw materials, monitoring of the production process and control of the final products are key actions in the prevention of these kinds of incidents. Attention should be paid to the type of raw materials used. For example, contamination by soil and insects most likely occur with materials like tubers, vegetables and fruit.

4.2 Naturally occurring harmful compounds

Certain foods may naturally contain substances that can be harmful to the public at large or to some specific consumer groups. For example, celery contains photosensitising **psoralens** that may cause severe burns in people handling and even in some cases consuming them. Liquorice contains **glycyrrhizinic** acid, which causes elevated blood pressure. Expectant mothers are therefore advised to avoid liquorice for this reason and also due to suspected harmful effects on the foetus. Many beans (for example red kidney beans) contain special proteins, **lectins**, that may cause stomach pain and diarrhoea, unless the beans are properly cooked. In Finland, some wild edible mushrooms contain toxic substances that have to be eliminated by proper treatment (blanching or extensive cooking) before consumption.

In general, naturally occurring harmful compounds in traditional foods are rarely present in quantities that could cause poisonings, or the traditional processing methods are sufficient to eliminate them. Problems may arise when a food is introduced into new cultural settings in which they have not been previously used, and therefore instructions on the proper preparation and processing should be made available (such as the thorough cooking of beans).

Foods may also contain as major components substances that are harmful to specific consumer sectors. Dairy products containing lactose may cause indigestion in people that are not able to break down this sugar due to the lack of the functional lactase enzyme in their intestine (approximately 13% of the Finnish population, more than 90% of the people in Far East). Many of these individuals can tolerate fermented milks and ripened cheeses well, although nowadays in Finland there is a wide range of low lactose or lactose-free milk products available for consumers.

Likewise **gluten**, present in common cereals (wheat, oats, rye), causes problems for those suffering from coeliac disease (an autoimmune disease where the small intestine is attacked and damaged upon the ingestion of gluten, a protein present in these grains). Avoiding products containing gluten and using gluten-free alternatives (maize, rice, buckwheat, sorghum, quinoa, etc.) are the only options in these cases. If a company makes both gluten-containing and gluten-free products, extreme care should be devoted to keeping the production lines completely separate so that the gluten-free products do not get contaminated even by trace amounts of gluten-containing cereals.

Food **allergens** are food-associated proteins or in some cases small molecular weight compounds that can cause quite severe reactions in sensitised, susceptible individuals. Allergens are quite common in almost all types of foods, but fish, eggs, milk products, cereals, and especially nuts and peanuts are foodstuffs that are most often associated with allergic reactions. Food allergies are common in children and tend to be transient, but permanent allergies also present in adults are not uncommon. If a foodstuff contains or is suspected to contain known allergenic components, the food label or declaration of contents should include a relevant warning (see Chapter 7).

4.3 Food additives

Food additives are substances that are **intentionally** added to foods to obtain certain technological benefit (better keeping quality, better consistency, control of microbiological hazards, prevention of oxidation, etc.). It should be emphasised that authorised food additives have been evaluated for safety and when they are used according to the instructions, are safe for the general population.

In fact, we can hardly imagine modern food chains without the advantages of food additives. Nevertheless, some additives can be harmful to a certain subset of consumers. Allergies are a common example. For example, benzoic acid that is used as a preservative in juices can cause allergies in some individuals, and sulphur dioxide and sulphites may cause problems in asthmatic individuals. Azo-dyes (common in sweets, soft drinks and confectionery) may also cause adverse reactions.

For some food additives an acceptable daily intake (ADI) has been defined on the basis of toxicological studies. ADI refers to the amount (expressed as mg/kg body weight/day) of the additive that is considered safe to be consumed every day throughout a person’s lifetime. For example, the ADI of benzoic acid is 5 mg/kg/day, and its maximum allowed level in juice products is 200 mg/litre. Therefore, an adult could consume 1.5 litres or more of juice that contains benzoic acid each day without any anticipated harmful consequences. For some additives, the

ADI can be accidentally exceeded in children, but this is not of concern, because the ADI refers to long-term consumption.

4.4 Pesticides and veterinary drug residues

The relevant EU legislation concerning pesticide and veterinary drug residues has been described in Chapter 2. The successful implementation of the relevant regulations depends on the collaborative effort of authorities, responsible primary producers and the food industry. In case of veterinary drugs, veterinarians prescribing drugs play a key role, while farmers are responsible for following the stipulated withdrawal periods before allowing animal products from treated animals to enter the market. Efficient and affordable analytical services are essential for verifying both the compliance and product safety. Antibiotics are the most monitored group of drugs, and dairy plants rely on their own tests on antibiotic residues to ensure the safety and technological quality of the raw milk they receive.

Regarding pesticide residues, farmers and professional users have to understand the properties of the pesticides, their proper use and the risks involved. Therefore, in Finland, farmers and other persons who regularly handle pesticides have to pass a special examination. Of course, the analytical control of residues by authorities is also necessary to verify compliance (see Chapter 5).

4.5 Toxins formed by filamentous fungi and algae

These have already been discussed in Chapters 2 and 3. Although they are microbial metabolites and thus efficiently controlled by good hygienic conditions, toxin-producing fungi are so common in the environment that the complete elimination of mycotoxins from the food chain is not possible. Therefore, the EU has defined MRL limits for the most common and potent mycotoxins.

It should be noted that although actual human foods rarely contain dangerous amounts of mycotoxins, they can be a veterinary problem in animal production. Mould-infested feed and cereals are often fed to animals resulting in poor growth, liver and kidney failures and reproductive problems. In addition to *Aspergillus* and *Penicillium* moulds, *Fusarium* moulds are especially common toxin producers that infest cereals in particular. Good storage conditions (dry and well-ventilated) and high-quality silage are the best ways to eliminate fungal infestations from feeds.

4.6 Food contact materials

Food contact materials, especially those used in packaging, may interact with food, and chemicals from the food contact materials may migrate into food. The rate of migration depends on the temperature and duration of the food contact, the chemical nature of both the material and the food (food might be wet, fatty or dry, and the types of chemical that could migrate into them are different in each of these cases).

As already mentioned in Chapter 2, EU legislation on plastics used for food contact is very detailed, defining both the overall acceptable migration and, for many substances, also the specific MRL values. In practice, a food manufacturer must require a **certificate of compliance** from the provider of the food contact plastic and plastic materials.

5 Monitoring of food safety: official controls

Primary producers and food establishments have the main responsibility for food safety in Finland. The role of official control is to ensure the implementation of the relevant regulations and to check the quality of both food operations and food products. The Finnish Food Authority, under the Ministry of Agriculture and Forestry, coordinates the food safety policy and food inspections via the Regional State Administrative Agencies.

These agencies supervise food inspection at the municipal level. The key actors are municipal health inspectors and veterinarians, who control the whole food chain from primary production to retail sales by regular inspections. An essential feature of the system is that the outcomes of the inspections are made known to the general public using the Oiva reporting system (see section 5.4).

5.1 The organisation of official food control in Finland

Food establishments have the principal responsibility for food safety in the EU. Companies should have their self-monitoring plans in place, have an established HACCP system and follow the other requirements laid down in the relevant EU regulations (see Chapters 2 and 6). The role of the authorities is to implement the legislation and coordinate the required actions.

The central ministry in matters related to food safety is the **Ministry of Agriculture and Forestry**. The **Ministry of Economic Affairs and Employment** (Customs and food imports), and the **Ministry of Defence** (the provision of food for the defence forces) have supplementary roles.

The **Finnish Food Authority** operating under the Ministry of Agriculture and Forestry supervises the implementation of the food law and safety regulations and conducts scientific research related to food safety and animal health. The Finnish Food Authority is also the national 'competent authority' as defined in EU Regulation 852/2004.

The Finnish Food Authority supervises and coordinates the six **Regional State Administrative Agencie**s spanning the whole country. One of the tasks of these agencies is to ensure that food control is properly arranged at the municipal level (Figure 3).

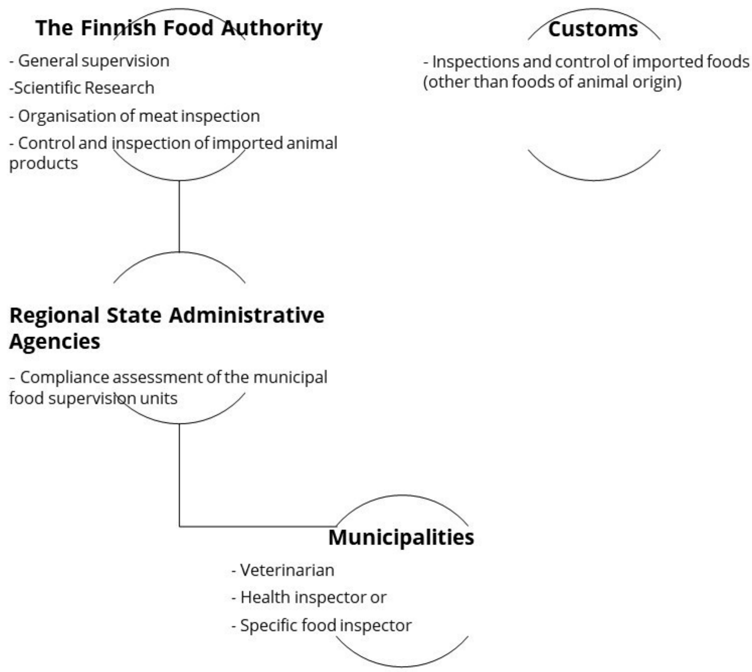

Figure 3. The organisation of food safety control in Finland

5.2 Official food control at the municipal level

Food establishments are subject to regular inspections (at least once per year), performed by municipal veterinarians and especially municipal health inspectors. The whole food chain from primary production to food manufacture and retail sales is subject to an inspection programme. The control already starts with the founding of an enterprise dealing with food. All food establishments have to be **notified** to the local authorities before the start of operations. In the case of an establishment dealing with animal-derived foods before submitting them to retail sale, facilities have to be **specially approved**, and the application has to contain a self-monitoring plan. In notified establishments, the self-monitoring plan has to be presented at the first time of inspection.

Food establishment inspectors have to have a degree in relevant disciplines, either from a university of applied science or a university. To ensure uniform procedures in all enterprises and throughout the country, the Finnish Food Authority has published very detailed instructions for the inspection of food establishments.

For **notified food establishments**, the main focus is on the quality of a self-monitoring plan, facilities and equipment, cleanliness and pest control, personnel, hygienic work practices and training, hygienic handling of the food, correct temperatures during manufacturing and storage, hygienic practices during selling and catering, the composition of the products, the use of additives, labelling, packaging and food contact materials, traceability and reclamations, sampling and required analyses.

For **approved food establishments**, there are some additional requirements specific for meat, fish and eggs, such as the receiving and traceability of animal products and special rules related to the labelling and selling of animal products. An important exception to the general scheme of municipal food inspection is meat inspection in slaughterhouses, which is always performed by the Finnish Food Authority.

5.3 Accredited food research laboratories

Food control involves quite a lot of sampling as well as microbiological and chemical analysis. Although many larger food companies have their own in-house laboratories for product development and quality control, self-monitoring operations include a certain number of official laboratory analyses that have to be performed in official food control laboratories. These laboratories have to be accredited and follow the SFS-EN ISO/IEC 17025 standard. Currently, there are 35 accredited food research laboratories across Finland. Most of these laboratories are private enterprises, but they always have to be approved by the Finnish Food Authority.

5.4 OIVA reporting system

An essential aspect of the transparency of the food chain is that the outcomes of the inspections of food establishments are available for the general public. In Finland, this is ensured by the Oiva reporting system (Oiva means ‘excellent’ in Finnish). The Oiva reporting system was initiated by the Finnish Food Authority to give the public and consumers sufficient information about the hygienic quality of the food establishments they visit as customers.

An Oiva report summarises the findings of the inspection. The results of the evaluation are indicated by emoticons: 😆 = Excellent, 🙂 = Good, 😐 = To be corrected to ☹= Poor (Figure 4). The lowest grade is an indication of the overall quality of the activities. Thus, a single less-than-satisfactory result in some aspect of the inspection is enough to downgrade the whole establishment. Food establishments must keep the Oiva document visible in the premises, on the website of the establishment and on the following website: www.oivahymy.fi. There are similar systems in use in other European countries and the USA. As in Finland, emoticons are used in Denmark, Norway and France.

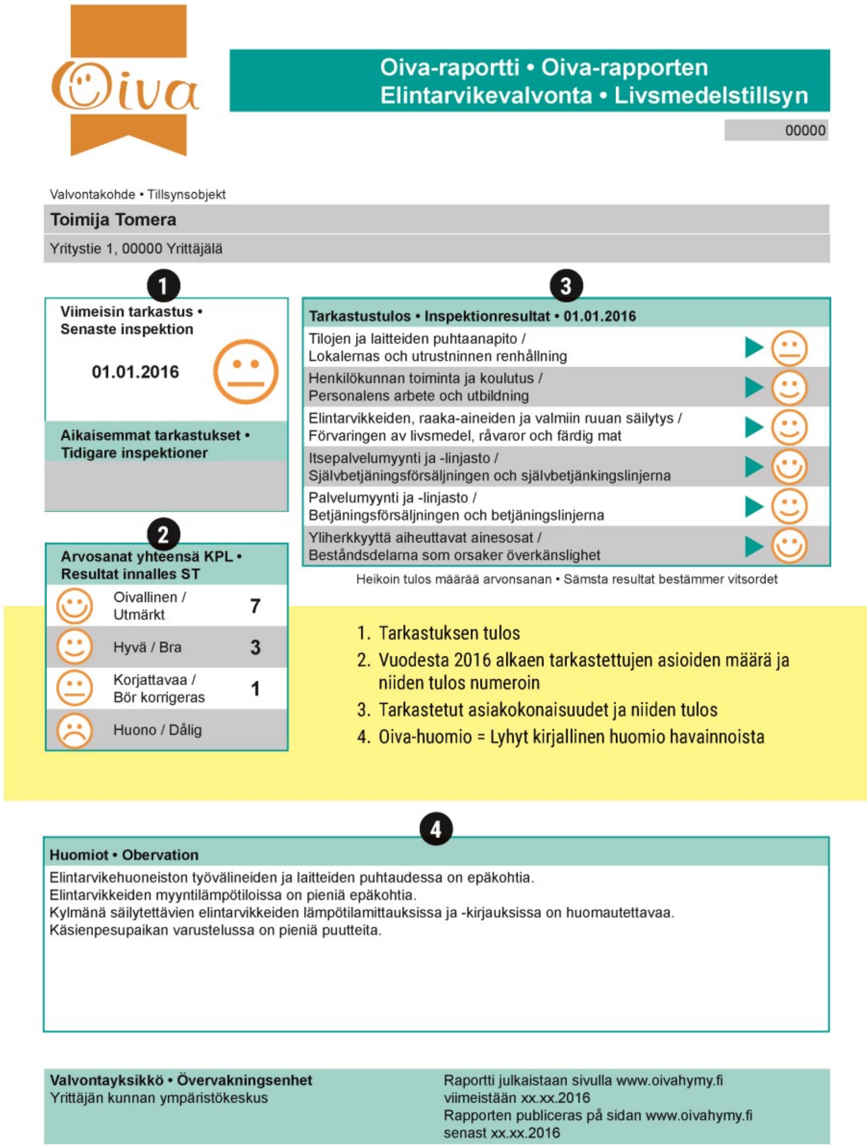

Figure 4. An example of an Oiva report [7]

In the report the date of the inspection (in this case 30.04.2013) is given, together with the overall evaluation of the establishment (in this case = To be corrected). The different aspects evaluated (cleanliness of facilities and equipment, performance of the staff and their training, etc.) together with the respective grades are indicated in the box in the upper right corner.

[7] Finnish Food Authority, 2020

6 Food safety management systems

Food safety management is the responsibility of food operators, companies and enterprises. Responsibilities are laid out in legislation and at a minimum involve the formulation of a self-monitoring plan based on the HACCP and to ensure that the personnel are well trained and knowledgeable of food hygiene and hygienic practices.

In Finland, the latter requirement is taken care of by requiring a hygiene passport from all persons working in food processing and the food trade. There are also non-mandatory but highly recommended food safety certification programmes that can be implemented, such as the ISO 22000:2018, especially by larger companies.

One of the key legal documents in the EU that defines the responsibilities of food companies and enterprises is Regulation (EC) No 852/2004 on the hygiene of foodstuffs. As already pointed out (see Chapter 2), this regulation specifically requires food companies to implement the Hazard Analysis Critical Control Point (HACCP) principles as a critical element of their self-monitoring plan, and to ensure that personnel are sufficiently trained in food safety and hygiene. In addition to these mandatory requirements, food establishments are encouraged to comply with specific standards that further guarantee the high level of operations and the safety of products.

6.1 The HACCP approach and prerequisite programmes

HACCP is a food safety management system (FSMS) that identifies and controls hazards at critical control points to minimise risks to food safety. The seven principles of the HACCP approach have already been outlined in Chapter 2. The aspect that should be highlighted here is the '**Prerequisite Programmes'** (PRPs) that should be in place before the HACCP can be properly established.

These programmes include the proper design of facilities (see Chapter 3) and equipment, written specifications for ingredients, products and packaging materials, supplier control, sanitation and pest control, personal hygiene, and documented hygiene training of personnel, etc. In Finland the documented evidence of hygiene training is ensured by the compulsory hygiene passport that all people working in approved food establishments must have (see Chapter 3).

Food safety management systems require proper documentation and maintenance of records to demonstrate that the system is being implemented satisfactorily and managed effectively. Records could include product specifications, deliveries, temperature monitoring, humidity monitoring, pest control, sampling and microbiological data records, cleaning schedules, staff training and so forth.

6.2 Food safety certification programmes

Certification of a FSMS implies new responsibilities for food businesses, especially regarding management operations, internal audits, managing traceability, and ensuring the functionality of processes. At best, a certified FSMS implies competitive advantage as it encourages the food business to continually develop its processes but allows for the integration of management of a wider array of operating systems including, besides food safety, quality, and environmental and occupational safety.

While the HACCP approach is mandatory for all food establishments (except for primary production), there are different certification programmes that food companies, especially those involved in exports, can implement in order to verify the correct functioning of an FSMS, the most important ones belonging to the ISO 22000 family of standards.

The other widely used food safety certification programme, FSSC 22000 (Food Safety System Certification), includes the ISO 22000 standard, but this is complemented by sector-specific technical standards, such as ISO/TS 22002-1 (this technical standard is designed to ensure that PRPs are in place). In the latest version of the ISO 22000 standards, ISO 22000:2018 emphasises the Plan-Do-Check-Act (PDCA) cycles and their applications in both organisational and operational planning (Figure 5).

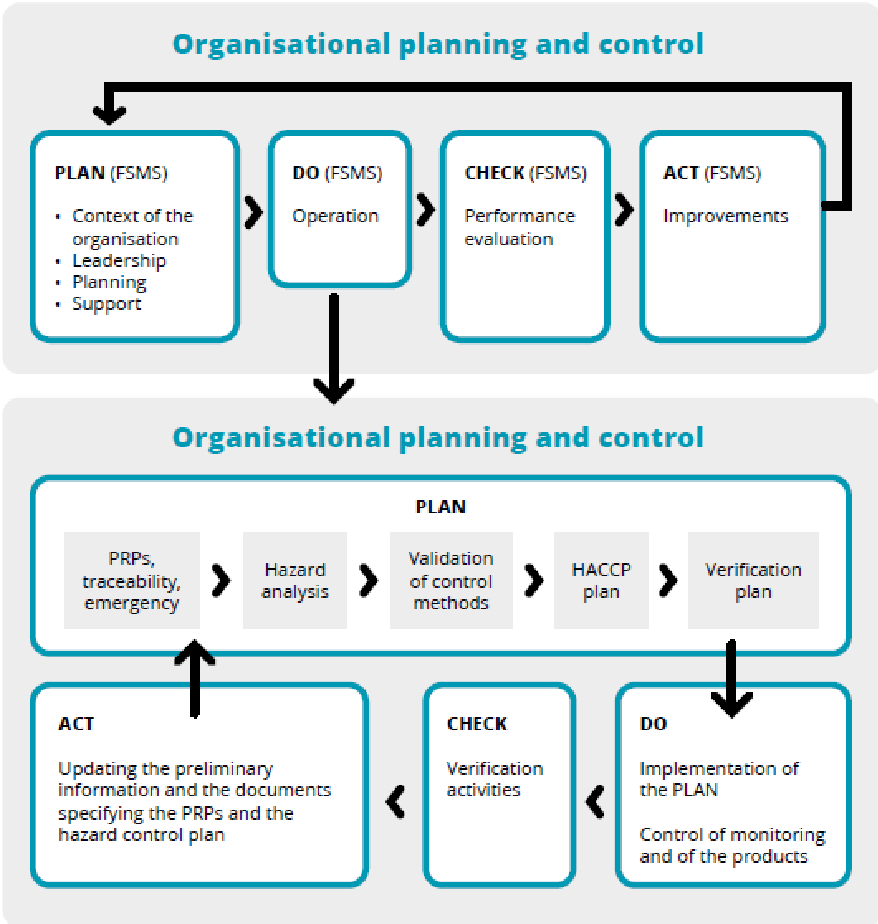

Figure 5. The organisational and operational PDCA cycles of ISO 22000:2018

It should be noted that the 'DO' part of the organisational PDCA cycle is actually the operational PDCA cycle, and in practice the implementation of HACCP. The central aspect of the PDCA cycles is that they are expected to run continuously. The system is never 'ready' but is subject to constant improvements on the basis of the practical experiences obtained during the everyday running of the enterprise. ISO 22000:2018 lays out some special duties on management. These include:

- Ensuring that the FSMS is established in the scope and scale that is appropriate for the organisation
- Ensuring that the resources necessary for the FSMS are available
- Communication (internal and external)
- Ensuring that the FSMS is evaluated and maintained
- Appointing a food safety team and team leader

It is worth noting that the food safety team leader does not necessarily have to be a member of the management but has to have a clearly defined independent role. The main task of the food safety team leader is to ensure that the FSMS is established, implemented, maintained and updated. This naturally includes the organisation and management of the work of the food safety team and ensuring the proper training and competencies of the team members. The food safety team leader also reports to the top management.

ISO 22000:2018 is only a food safety certification programme and thus does not cover quality or environmental issues, which are covered by ISO 9001 and ISO 140001, respectively. A company implementing food safety, quality and environmental management under the ISO family of standards must, therefore, implement these separately.

It is important to note that HACCP is central to all food safety certification programmes. During the auditing of a certification programme, the auditor mainly checks that the *Codex Alimentarius's* HACCP principles are adhered to. All the operations should also adhere to Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP) and Good Storage Practices (GSP). In addition, the auditing should also demonstrate that there are no conflicts between certification programmes, HACCP and legislation.

6.3 Other certification programmes

As mentioned earlier, the FSSC certification programme includes the ISO 22000 main standard, field specific technical ISO/TS 22002-1 standard and FSSC additional requirements. These are, however, quite demanding. FSSC is compatible with other ISO standards. The management system is easy to implement for those companies that implement the ISO 9001 quality standard and the ISO 140001 environmental standard. As the standard consists of other standards, there are overlaps that can cause difficulty in implementation and also make interpretation difficult.

The International Food Standard (IFS) is a food safety certification system used widely in France and Germany, and is a compilation of several standards, also covering quality management. The IFS applies several risk assessment tools, which makes it easily applicable for different sectors. The IFS also takes ethical issues into account.

The British Retail Consortium Global Standard (BRCGS) is a compilation of standards for several sectors, including non-food sectors, and also covers quality management. It has clear requirements, which reduces the time used to interpret and apply the standards. It is quite demanding in detail and thus can limit the company in operations.

6.4 Food Safety Certification Programmes – to implement or not to implement?

The main difference between food safety certification programmes and the normal HACCP procedure is the more formalised structure and documentation and more clearly defined responsibilities of the former.

It should be noted that food safety certification programmes such as ISO 22000:2018 are not mandatory, and small companies with limited human resources should seriously consider whether it is worth the effort (there is no point in appointing people to multiple roles just to formally satisfy the standard) as long as HACCP is in place. If HACCP is in place and is functioning, the implementation of food safety certification programmes such ISO 22000:2018 is relatively easy, and larger companies aiming at food exports should seriously consider them.

6.5 Setting up an in-house control system for managing food safety and quality

Here we describe how to set up an in-house control system for measuring food safety and quality based on the HACCP principle, which can then be developed further for auditing.

The task should essentially be handled by a team including staff working on quality and safety management as well as those in the production team itself. After naming the team, the subsequent steps are as follows:

- Preparation of product descriptions:
  This includes:
  - Composition
  - Processing form
  - Chemical/physical values, sensory values and microbiological values
  - Appearance and packaging
  - Storage and marketing conditions
  - Shelf-life
  - Use
  - Target group
- Preparation of production description
  This includes describing the path taken by the product through the production plant in all its stages, in the form of a flow chart. All important technical information (e.g. temperature, time, etc.) must be included. It is recommended to prepare a ground-plan of the work rooms to demonstrate the flow of machines, personnel, products and production.
- Hazard analysis
  A list of hazards that can occur in any of the individual processes should be made. Measures to remove or reduce these hazards should also be listed and consideration made of biological, chemical and physical hazards. An estimation of the probability of the occurrence of the hazards named and their impact on the final consumer should also be made.
- Determination of critical control points (CCPs)
  At this stage, the points within the production that constitute a potential risk to the end-consumers' health, but which can be

prevented, removed or reduced to an acceptable level by properly targeted control and monitoring measures is made.

- Determination of critical limits
  Once CCPs are determined, limits should be fixed to indicate whether the CCP is under control or not. These limits thereby indicate what is and what is not acceptable. These should be kept quite simple and quick to determine. Suitable values include: temperature limits, time limits and pH values.
- Establishment of monitoring procedures
  Required observations or measurements have to be specified for each CCP to ensure that the set limits are adhered to. Persons responsible for monitoring, when and in what form are also determined.
- Establishment of corrective action
  It is essential to plan the activities that come into play if a value exceeds a critical limit.
- Monitoring the effectiveness of an in-house control system
  In order that an in-house control system runs smoothly and effectively, it is necessary to check its efficiency regularly. This can be done by testing final products, or controlling whether monitoring procedures can be performed.

Documents can be drawn up as individual files or for larger companies with several products, an HACCP manual is prepared, where product groups and required measures are described in individual chapters. An example of an in-house control documentation system is demonstrated in Table 5.

Table 5. Example of in-house control form for food safety and quality

Product Name										
Product Description	**Composition**	**Processing Form**	**Chemical values**	**Physical values**	**Sensory values**	**Appearance and packaging**	**Storage conditions**	**Cooking instructions**	**Shelf-life**	**Target Group**
Production Description	Draw flow chart and describe each stage									
Hazard analysis	**Hazard**		**Limits**		**Monitoring Procedure**		**Corrective action**		**Measure for checking effectiveness**	
Process stage										
Process stage										
Process stage										
Process stage										

7 Food labelling in the European Union

Consumers are entitled to receive the necessary information about the composition and relevant properties of foods. Food labelling is, therefore, very strictly controlled in the EU. Regulation (EU) No: 1169/2011 lays down the basic principles and the minimum amounts of information that food labels must contain, including any warnings (for example in case of allergens) that might be relevant to the safety of certain consumer groups.

Genetically modified foods/food components must also be declared (Regulation (EC) No: 1830/2003). Nutritional and health claims are also a special case covered by Regulation (EC) No: 1924/2006. The general principle is to keep foods and medicines as separate categories. Therefore, only generic nutritional claims and claims related to the reduction of disease risk factors are allowed – not claims indicating an ability of a food to cure or prevent a disease.

Essential consumer information on the composition and nutritional quality of food and also of some essential safety aspects is provided by food labelling. Therefore, European legislation defines the minimum requirements for food labelling, including the necessary safety information and the definition of permitted and prohibited claims associated with food.

7.1 The aims and scope of Regulation (EU) No: 1169/2011

According to Article 3 of the regulation, '*The provision of food information shall pursue a high level of protection of consumers' health and interests by providing a basis for final consumers to make informed choices and to make safe use of food, with particular regard to health, economic, environmental, social and ethical considerations*.' A particular concern is the protection of a consumer from misleading information (Article 7). Misleading information can refer to the presence or absence of particular food ingredients, to some properties of food that it actually does not have, or that it in a unique way possesses characteristics that in reality all similar food share.

7.1.1 Minimum compulsory information

The minimum information that should be made available to the consumer includes the following topics:

- The name of the food product
- List of ingredients
- Net quantity
- The quantity of certain ingredients or categories of ingredients; **including warnings**, if needed (for example: '**May contain nuts'**)
- **The minimum durability time or the 'use-by date'** (and date of freezing in case of deep freeze products)
- The country of origin, if a lack of this information might mislead the consumer
- The number or symbol of the production lot
- Instructions for storage, if needed
- Instructions for use, if needed
- The name or business name and address of the food business operator
- Alcohol content, in case the alcoholic content is higher than 1.2 % (v/v, liquid foods) or 1.8 % (w/w, solid foods)
- Nutrition declaration

7.1.1.1 What is a nutrition declaration?

The mandatory nutrition declaration shall include the following: energy value; and the amounts of fat, saturates, carbohydrate, sugars, protein and salt. Where appropriate, a statement indicating that the salt content is exclusively due to the presence of naturally-occurring sodium may appear in close proximity to the nutrition declaration.

The content of the mandatory nutrition declaration may be supplemented with an indication of the amounts of one or more of the following:

- Mono-unsaturated fats
- Polyunsaturated fats
- Polyols
- Starch
- Fibre
- Any of the vitamins or minerals listed in Annex XII3 of Regulation (EU) No 1169/2011

7.1.2 Exceptions and special cases

When the space for the label on the package is limited (less than 10 cm^2), only the name of the food, a list of ingredients that may cause allergies or intolerances, the net quantity, the date of minimum durability or the 'use by' date, and the nutrition declaration are required. There are some special rules for meat products, fish, eggs and fruit and vegetables:

- In the case of meat products, the information of the country where the animal was reared must be available. In the case of beef, also the country of birth, country of slaughter and the country of provenance must be declared, if these phases have occurred in different countries. For sausages and other processed meats, the country of production must be declared, but not necessarily the origin of the meat.
- For fresh fish, the date and place of the catch must be declared.
- The shells of unpacked eggs must be labelled using a country code and symbols that indicate the production type (organic, free range hens, etc.) must be declared.
- For vegetables, compulsory information includes the packager, the country of origin, the quality class, net weight and the name of the product in case the content is not visible. In the case of unpacked vegetables, the country of origin and the quality class must be visible in places where they are sold.

7.1.3 Warnings- when are they needed?

Although food is supposed to be generally safe, there might be special consumer groups or occasions when certain foods or at least their excessive use should be avoided. In these cases, a clearly formulated warning should be included in the information given in the food label. The most common examples are the following:

- When the food contains or may contain allergens (listed in the Annex II of Regulation (EU) No 1169/2011), such as cereals, crustaceans, eggs, fish, peanuts, beans, soybeans, milk, nuts, celery, mustard, sesame seeds, sulphur dioxide and sulphides, lupin seeds, molluscs.
- When polyols (sugar alcohols) are used as sweeteners (the label must contain the phrase: 'Excessive consumption may produce laxative effects').

- When foods contain aspartame or aspartame salts, the following phrase 'Contains aspartame (a source of phenylalanine)' shall appear on the label in cases where aspartame/aspartame-acesulfame salt is designated in the list of ingredients only by reference to the E number or 'Contains a source of phenylalanine' in cases where aspartame/aspartame-acesulfame salt is designated in the list of ingredients by its specific name.
- When foods (confectionary, drinks) contain glycyrrhizinic acid (liquorice) or ammonium salt (the warning phrase 'People suffering from hypertension should avoid excessive consumption').

7.2 Genetically modified foods

The intention of Regulation (EC) No 1830/2003 is to provide information for consumers to allow them to make an informed choice. In the case of pre-packaged GM food/feed products, the **list of ingredients must indicate 'genetically modified' or 'produced from genetically modified [name of the organism]**'. In the case of products without packaging, these words must still be clearly displayed in close proximity to the product (e.g. a note on the supermarket shelf).

7.3 Nutritional and health claims

Nutritional and health claims refer to cases where food or some of its ingredients have a particular nutritional quality or function or could have beneficial health effects. These types of claims should be based on well-established scientific facts, and the types of allowed claims are strictly regulated.

7.3.1 Nutritional claims

A 'nutritional claim' refers to any claim that states, suggests or implies that a food has particular beneficial nutritional properties due to:

- The energy (calorific value) it:
    - provides
    - provides at a reduced or increased rate, or
    - does not provide

- The nutrients or other substances it:
  - contains
  - contains in reduced (e.g. reduced salt) or increased proportions (e.g. high in fibre) or
  - does not contain

Nutritional claims are only permitted if they are listed in the Annex of Regulation (EC) No 1924/2006, most recently amended by Regulation (EU) No 1047/2012. An example of the permitted claim and its uses is the phrase 'Low energy'. The preconditions of its legal use are the following: '**A claim that a food is low in energy, and any claim likely to have the same meaning for the consumer, may only be made where the product does not contain more than 40 kcal (170 kJ)/100 g for solids or more than 20 kcal (80 kJ)/100 ml for liquids. For table-top sweeteners the limit of 4 kcal (17 kJ)/portion, with equivalent sweetening properties to 6 g of sucrose (approximately 1 teaspoon of sucrose), applies.'**

7.3.2 Health claims

In the EU, foods and medicines are strictly different categories and no claims referring to an ability of a food to prevent, cure or ameliorate any disease are allowed. However, foods also have health effects, and therefore they can in certain circumstances be claimed in food labelling. These are outlined in Regulation (EC) No 1924/2006. A health claim indicates that there is a relationship between health and the food product and must always be substantiated by scientific evidence, whose adequacy is assessed by the European Food Safety Authority (EFSA).

7.3.2.1 Types of permitted health claims

There are three types of health claims that are permitted:

Functional health claims (or Article 13 claims) refer to growth, development and functions of the body, psychological or behavioural functions or to slimming and weight control.

Risk Reduction Claims (or Article 14(1)(a) claims) refer to reducing a risk factor in the development of a disease. For example: 'Plant stanol esters have been shown to reduce blood cholesterol. Blood cholesterol is a risk factor in the development of coronary heart disease'.

Claims referring to children's development (Article 14(1)(b) claims) form the third category. For example: 'Vitamin D is needed for the normal growth and development of bone in children'. A list of accepted Article 13 claims is annexed to the regulation. Each Article 14 claim requires, as mentioned above, a specific authorisation process and evaluation by the EFSA.

8 Food safety and quality management along food value chains

A food value chain consists of all the stakeholders that participate in production and value-adding activities to make food products. Alliances or partnerships are formed by different actors around different goals that are reflected in the final product. These partnerships are often characterised by interdependence, collaboration and mutual support and create shared value. Food value chains that function in concert, on shared vision and information, and that are based on the commitment of all the stakeholders to mutually acceptable agreements are characterised by high-level performance, good resource management, trust, responsiveness and traceability.

The Finnish approach to managing food value chains has developed into a world-class system ensuring consumer trust and the production of safe, high-quality food. With agriculture having been the foundation of the Finnish economy until the 1950s, most foodstuffs consumed in Finland are still of domestic origin and food product sales represent a major part of agricultural income. Quality and safety of food products are based on management of the food value chain from farm to fork (Figure 6).

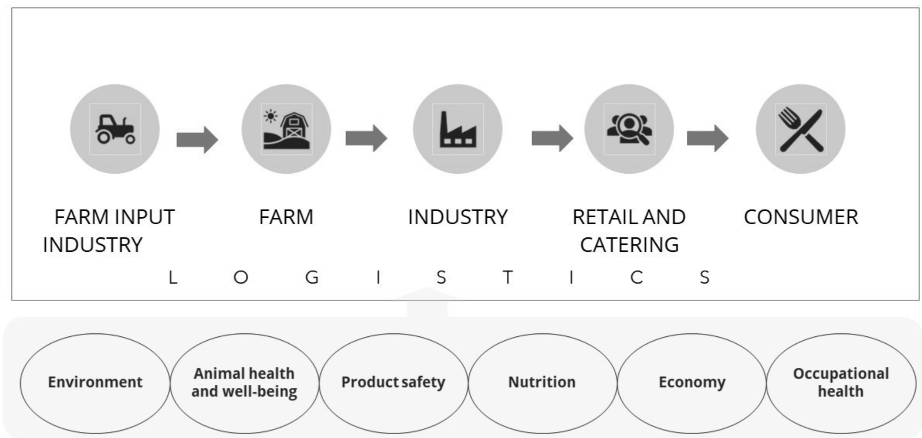

Figure 6. Finnish food value chain from farm to fork

8.1 Quality as a part of the food value chain

Food value chains in Finland are incorporated in a quality management system, where the whole production process has been directed to produce excellent food products, with a focus on meeting consumer needs. The processes have required teamwork between the different stakeholders and proactive management, especially on one hand by farmers at the production stage and, on the other, by food processors.

Defining the level of quality that satisfies the consumer but that is also economical to the food business is an intrinsic part of the quality management process. Furthermore, processes are specific, based on written specifications, and procedures comply with legislation, the HACCP principle and international standards. Processes are open to inspection and auditing, and are transparent and controlled. Transparency is critical to the processes as is communication to all interested parties, including the public. This has been the building block for consumer trust in the Finnish food industry. Consumers are essentially interested in questions relating to where food is from, who has produced it and how, as well as its value.

Effective food safety and quality management systems are therefore key to safeguarding the health and well-being of people, fostering economic development, and improving livelihoods by promoting access to domestic, regional and international markets.

8.2 Traceability

Traceability is the ability to track any food, feed, food-producing animal or substance that is used for consumption, through all stages of production, processing and distribution. A traceability system is basically the reverse process of a food value chain.

A traceability system is, in essence, a risk-management tool that allows for the identification of food fraud or quality deficiencies and for the withdrawal or recall of products that have been identified as unacceptable, for instance in the case of:

- Outbreaks of diseases in animals that can be traced to humans
- Presence of chemicals exceeding the acceptable limits in feed and food
- Microbial contamination of food or feed exceeding acceptable limits in feed and food
- Contamination of food or feed by foreign substances

There are several reasons why stakeholders in the food value chain should invest in the development of traceability. Public safety is the most important of these. Food sector stakeholders play a central role in minimising the risks of food fraud and food adulteration, and in the management of food-borne diseases and environmental emergencies. Creating a good traceability system also enhances risk management in business, decreasing food product recalls and liability costs. In terms of the entire food value chain, productivity is more efficient and cash flow is improved. A well-managed traceability system also allows for innovation and co-creation among stakeholders and finally also helps to reduce food waste, which is a growing problem in the food sector. From the consumer's perspective, a well-managed traceability system helps to enhance their confidence in food products.

Tools that are used for traceability include product identification and labelling, different pieces of digital software and RFID systems. The following principles should be followed when designing a traceability system:

- All stages of receiving, production, processing and distribution are covered.
- All raw material suppliers are identified and documented.
- All components/ingredients used in the product are identified and documented.
- All supplied customers are identified and documented.
- All products and intermediates that have been disposed of are identified and documented.
- All products are adequately labelled, identified and documented.
- Details are provided to authorities on-demand, voluntarily and in a timely manner

8.3 A note on water

Water is an essential part of food production and affects food safety more than we realise, as discussed in the introduction. In Finland, potable water is of very good quality and, for example, heavy metal concentrations in grains are low compared to other regions in Europe. Food produced in Finland generally has a low water footprint, which has been achieved by using good quality water in different food processes.

Good quality potable water is produced by municipalities and water cooperatives. The source of water is critical in determining its processing and affects the types of problems that a food producer or processor may encounter, such as the amount of water available and possible water shortages that may affect the production and processing of food.

Infrastructure used to provide and carry water is also critical, because electrical failures, burst pipes and other technical malfunctions will easily affect the production and processing of food. In terms of water quality, microbiological contamination is the biggest risk. Other factors that may affect water quality include the methods used to process it, such as chlorination.

The food industry would do well to ensure that its processes make effective use of water and energy. Wastewater can be a valuable source of water, nutrients and energy. Consequently, there are vast opportunities to ensure that wastewater from food processes is utilised sustainably, for instance, wastewater from fish farms can be used in agriculture, or fat deposits from meat processing wastewater could be used in biogas production.

8.4 A case example of the dairy and meat product value chains in Finland

Cattle production in Finland is mainly based on family-owned farms, but joint-stock companies also exist. Finnish farms are not very big, and an average dairy farm has about 39 animals[8]. On average, Finnish farms measure about 43 ha of fields[9]. At the end of 2018 there were about 6,700 milk producers and 285,000 cows in Finland.[8] The most common dairy cattle breeds in Finland are Nordic Red or Ayrshire (48%) with an average milk production level of 9,228kg/year, Holstein (46%) with an average milk production level of 10,243 kg/year and Finncattle or land races (1%) with an average milk production level of 4,072–6,972 kg/ year.

In 2017, the total milk production in Finland was 2,336 million litres or, on average, 8,534 litres/cow[8]. Finland's butter production in 2017 amounted to 53 million kg, whereas cheese production amounted to 86 million kg[8]. Organic milk production in 2018 amounted to 69 million litres from 145 producers[8]. Finnish raw milk is of high quality with low cell and bacterial counts. A simplified version of the dairy and beef products value chain is shown in Figure 7.

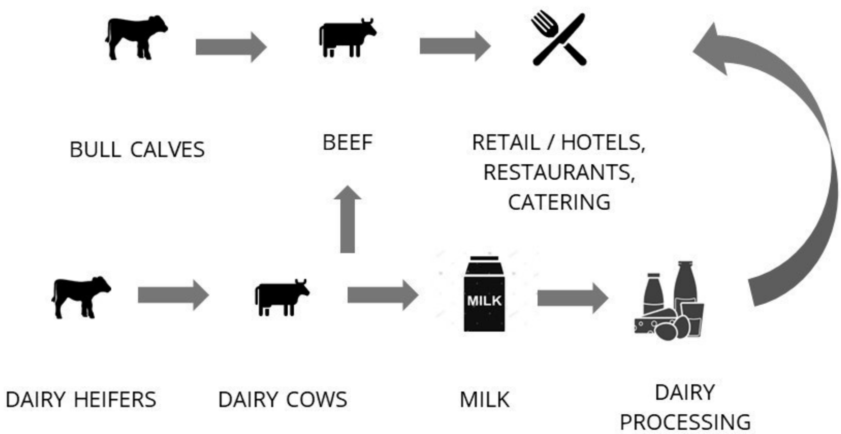

Figure 7. Dairy and beef product value chain in Finland

[8] Natural Resources Institute, Finland, 2018; Statistics Finland, 2018
[9] Eurostat, 2019

8.4.1 On the farm

When a calf is born, dairy heifers are taken onto dairy farms for milk production and after they are past the prime of their production, they are then slaughtered for beef. Bull calves are taken directly into beef production. Processors usually own their own slaughterhouses and dairies, from where dairy and beef products are then taken to retail shops or into the hotel, restaurant and catering sector, as well as public food services like schools, hospitals and homes for the elderly.

On the farm, each calf is given a name and an individual EU number. Registration is done within one week of birth and the register contains the EU number, the barn where the calf was born, its date of birth, the names of the parents and its breed. The calf is ear-tagged and it cannot be moved from the farm without tags.

Other than colostrum feeding, dairy cows in Finland do not suckle calves. Calves are fed with bulk tank milk or milk replacement. Cows are milked 2–3 times a day, usually with the help of milking robots that rinse the udder of the cow before milking. Daily milk production is usually about 30–40 litres/cow and thus they need to drink a lot of water. Cows are in milk 10 months per year and have a dry period of two months.

Most dairy cows are held in tied stall housing to ensure individual feeding and management, although this limits movement and social contact. Free stall housing is increasing, and this allows cows more freedom to move and interact with other cows. Grazing is very important for cows, and about 70% of Finnish farms allow for grazing. Grazing is mandatory for cows in tied stall housing for 60 days/year.

8.4.2 Health and welfare management on a cattle farm

The health and welfare of animals in Finland is very important. There has been increasing demand to pay attention to this issue, stemming from the general principles of food law, encompassing safety, responsibility and traceability. The underlying principles that guide the management of health and welfare of animals are partnership and open communication between all those that are involved: the farm, veterinarians, municipality, processors and the Finnish Food Authority, as well as research institutions. Governmental animal health advisory committees are involved to profile and categorise biological and chemical risks and their acceptable levels and to indicate measures to prevent risks of disease. It is important to ensure that farms comply with biosecurity measures and veterinary surveillance.

All farms are registered in the cattle health register, and veterinarians visit farms at least once a year, but most 3–4 times a year. During these visits, clinical inspections of the herd are conducted, including monitoring of cows' hooves and udders, which of course should also be monitored by the farmer. In the case of sick animals, a notification is made, and samples are taken for diagnosis, and finally the animals are treated appropriately. Antibiotics are used only for the treatment of bacterial diseases, and never as growth stimulators, and there are strict withdrawal periods during which milk from the treated cow is discarded.

During veterinarian visits, the farmer is also advised on disease prevention measures and management of the herd. Information about veterinary visits is recorded on a national database. There are also strict regulations related to the importation of animals, semen and feed. In addition, farm visits by outsiders are discouraged and generally restricted, and the health of farm workers is also effectively monitored.

8.4.3 Processing of milk and meat

All slaughtering in Finland has to take place in a slaughterhouse. Before slaughter, the farmer provides animal specific health information to the slaughterhouse veterinarian, including any diseases and treatments given over the past three months, the health situation of the herd, samples taken and their results and the name of the veterinarian in charge of the herd. The slaughterhouse veterinarian can access all this information from the national database.

Animals are collected in proper transportation vehicles on a predetermined date when they are of a particular size. The vehicles must be ventilated and maintain a steady temperature. Upon arrival at the slaughterhouse, animals are taken to a barn where they can rest. Bulls are kept separately in their own stalls, so that they do not fight each other and waste their energy.

It is important to keep the animals calm and rested right before slaughter to avoid deterioration in the meat quality, also referred to as 'stress-meat'.

Inspection and monitoring in the slaughterhouse is conducted by veterinarians (for larger slaughterhouses, these veterinarians are under the mandate of the Finnish Food Authority). Before slaughter, an ante-mortem inspection is conducted to ensure that animals are clinically healthy.

Animals are stunned, out of sight of other animals. Stunning is performed to prevent the animals from suffering. The animals' neck is then cut and blood collected, if it is to be used. It is important to bleed the animal properly to ensure that the quality and shelf-life of the meat is maintained. The animals are then flayed, and intestines removed. The carcass and organs are marked, at this time, to enable traceability.

A post-mortem inspection is conducted after slaughter, including a physical inspection of the carcass and internal organs, and sampling for chemical residues, *Salmonella* and other pathogens like *EHEC*, *Yersinia* and *Listeria* is also carried out. Following this, meat is cut and is processed into different products, chilled or frozen and placed on the market. Batch identification numbers on final products help with tracing the meat product all the way back to the farm.

In the case of milk, it is stored in a collection tank on the farm that keeps the milk cool. Milk is collected every two days, following a particular route plan with a milk collection truck, and is transported to the dairy. The average distance between the farm and dairy is about 76–80 km and from dairies to retails stores is 88–90 km. At dairies, the amount of milk is measured and its composition is analysed. Milk is also tested for chemical residues, bacteria and other pathogens. Following this, milk is processed into different products and sold. Some of the typical dairy processes for liquid milks involved are described in Table 4.

In addition to liquid dairy products, large amounts of both soft and ripened cheeses, powered milk and whey are manufactured in Finland. With these products, a high hygienic quality of raw milk is a prerequisite in the prevention of pathogens and spoilage organisms. Batch identification numbers on final products help with tracing the dairy product all the way to the farm level. Due to the stringent measures taken to control animal health and welfare, the causes of food safety concerns – if these arise – can be traced all the way back to the specific animal and even to feed.

Table 6. Typical dairy processes for liquid milks

Process	Description
Chilling	Once milk arrives at the dairy it is transferred to containers and kept cool at +3–4°C
Separation	Fat is separated from milk, which is important for producing fat-free milk and cream. This is done at temperatures between +45–55°
Stabilisation	The fat content of milk is set here, by adding cream or whole milk.
Homogenisation	Fat globules are mechanically dispersed to stop them from separating and rising to the top, leading to a more consistent texture and taste. This is done at +55–80°C, depending on product.
Thermisation	Milk is heated to +55–80°C for about 30 seconds, to reduce the amount of pathogenic bacteria, with minimal heat damage. Thermisation therefore increases shelf-life and allows for milk to be stored for processing later. In the EU, cheeses made of thermised milk are always distinguished from other cheeses.
Pasteurisation	Milk is heated to at least 72°C, for at least 15 seconds. Microbes and other spoilage organisms are destroyed at this stage. Pasteurisation does not affect the chemical composition of milk. High temperature pasteurisation is used in the production of cream (+80–84°C; 6–15 seconds) and fermented dairy products (+90–95°; 2–5 mins). The choice of technique is made depending on the intended use of the milk and its volume, access to equipment and target microorganisms.
Ultra-high temperature processing	Milk is heated to +135°C for 2–4 seconds and packed aseptically. UHT milk has a long shelf-life.
Batch pasteurization	Milk is treated here at +55–65°C for a few minutes. In this process milk is heated in small batches and rapidly cooled. Flavour is better preserved in this method.

Process	Description
Vitaminisation and addition of calcium	In Finland, vitamin D is added to zero-fat milk, sour milk and low-fat milk. This is because vitamin D is basically removed during separation. Calcium is added to the milk.
Lactose hydrolysis	Lactase is added to milk to speed up the process of breaking up sugars in the milk into glucose and galactose. The process results in milk having a slightly sweet taste.
Addition of probiotic lactic acid bacteria	Probiotic lactic acid bacteria are added to milk to enhance immunity against harmful microbes and balance the gut functions.
Packaging	Dairy products are packaged in order to prevent contamination from other substances and microbes, bad smell and taste. When products leave dairies, they are chilled and kept below +6°C.

8.4.4 Controls in milk and beef value chains in Finland

The legal framework related to milk and beef production is based on good agricultural practices (GAP) on the farm, good hygiene practices (GHP) on the farm, processing plants, during logistics and during retail operations, good manufacturing practices (GMP) at processing plants, and good storage practices (GSP) on the farm, at processing plants and during retail operations.

Animal health and welfare control is based on the Animal Protection Law (Council Directive 98/58/EC) and its five freedoms:

- Freedom from hunger and thirst
- Freedom from discomfort
- Freedom from pain, injury and disease
- Freedom to express normal behaviour
- Freedom from fear and distress

The hygiene package discussed in Chapter 2 also determines what must be observed on the farm, at processing plants and during retail operations. Finland's National *Salmonella* programme, which aims to keep *Salmonella* cases under 1%, is also central to the milk and beef value chain. The stringent identification requirements for cattle and farms as well as animal health records are also central to ensuring traceability.

8.5 A case example of the fish product value chain in Finland

The fisheries and aquaculture industry is one of the fastest growing branches in the agricultural sector, with global fish production estimated at 179 million tonnes in 2018 and 156 million tonnes reaching the plates of consumers[10]. In 2017, Finnish fish catches from both recreational and commercial sources amounted to 185 million kilograms, whereas aquaculture produced 14.5 million kg[11].

The most important fisheries species in Finland are Baltic herring (*Clupea harengus* L.) and sprat (*Sprattus sprattus*) in marine waters, whereas vendace (*Coregonus albula*) and pikeperch (*Sander lucioperca*) are the most important inland water species. In aquaculture, rainbow trout (*Oncorhynchus mykiss*) and European whitefish (*Coregonus lavaretus*) are the most important species. Finland also imports a lot of fish, mainly farmed salmon (*Salmo salar*), canned tuna (*Thunnus* spp.), frozen pollock (*Pollachius pollachius*) and shrimp.

Consumption of fish amounted to less than 4 kg per capita of domestic fish and above 9 kg per capita of imported fish[12]. In addition, to food for people, fish is also used as animal feed. While fish is a major source of protein, substantial losses in both quantity and quality can occur after capture or harvesting. In addition, the spoilage rate of fish is relatively high and it deteriorates very quickly, posing a safety risk to consumers if conditions to maintain the shelf-life are not observed from the start. The Finnish fish value chain is depicted in the following Figure 8.

[10] FAO, 2020. The State of World Fisheries and Aquaculture 2020

[11] Natural Resources Institute, Finland. 2018. E-yearbook of Food and Natural Resource Statistics for 2018.

[12] Natural Resources Institute, Finland. 2018. Fish Consumption 2018

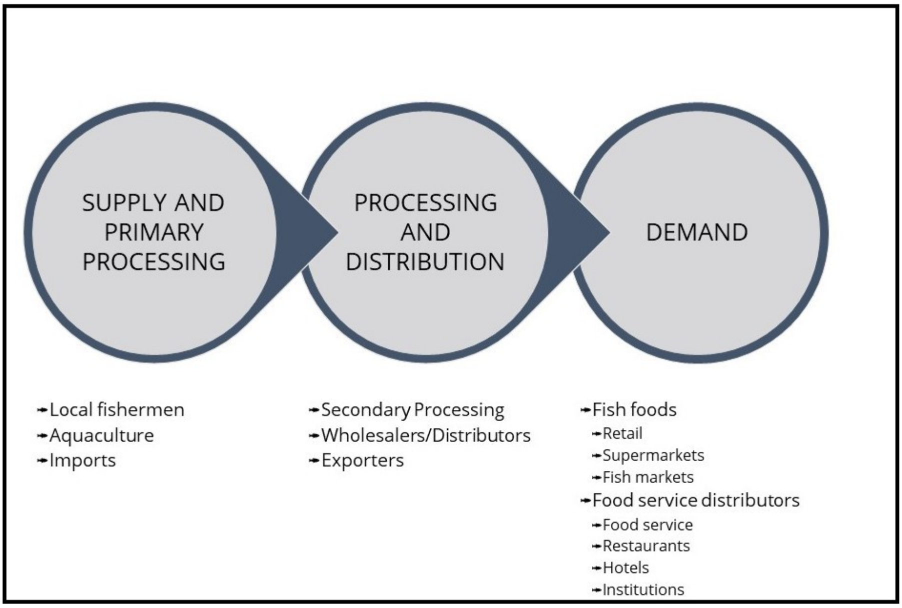

Figure 8. Fish product value chain in Finland

8.5.1 Fishing

There are several fishing methods in use. Here we discuss just two examples: trawling and gillnet fishing. Trawling is a fishing technique that involves pulling a fishing net, called a trawl, through the water behind one or more boats called trawlers. In small-scale fisheries, one trawl is towed from a boat, whereas in larger operations, two boats can associate in what is known as pair-trawling. Gillnet fishing involves laying vertical panels of nets to hang from a line with the help of regularly spaced floaters or corks holding the line on the surface of the water.

When harvesting fish from nets, fishermen should handle fish gently since fish get easily bruised. Fish should be held by the head and not the tail to ensure that their backs do not break and bruising is minimised. Fish should also not be thrown or dropped, for the same reasons. Catches are immediately placed into plastic containers with water at the same temperature as the water body. If the fish is gaffed, this should be done in the head.

8.5.2 Fish farming

Fish farming is a form of aquaculture (farming in water), where fish are raised in ponds, tanks or different enclosures, such as cages, in a variety of water bodies. In principle, safety and quality maintenance processes on fish farms in Finland are very similar to those that other animal farmers must follow.

The process essentially starts with site selection and examining the soil quality, in the case of pond culture, to ensure that the soil is free of pesticides, herbicides, heavy metals and other possible contaminants. Fish farming sites should also be free of weeds and located away from latrines/toilets, livestock and poultry.

The fish species to be farmed is also highly dependent on the water quality parameters. Water quality is one of the most important parameters that is analysed and monitored, not only during site selection, but also throughout the daily routine activities on the fish farm. Water temperature, pH, transparency, etc. are factors that influence fish feeding, fish metabolism and fish growth, overall. Furthermore, water temperature also affects algal growth and in case of disease or parasite infections, the higher the water temperature, the faster these usually spread.

Water should also be protected from both unintentional and deliberate contamination, for example faecal waste, chemical contaminants and other foreign materials. The fish farmer should monitor water quality daily to ensure that there are no surprises, for instance a water shortage or sudden changes in pH or other parameters.

Fish stocked on the farm should originate from healthy farms, nurseries or hatcheries. It is important to ensure that fish come from a non-infected source. The transportation of fish from a nursery or hatchery should be done quickly, with minimal disturbance to the fish, and fish should fast for a day before being moved. This is to avoid inflicting stress on the fish, making them susceptible to disease and infection.

One of the first activities is to quarantine new, incoming fish in their own water tank or pond to ensure they acclimatise to the new conditions and to facilitate their observation. Fish density in individual tanks, ponds or cages should not be too high. Furthermore, dead fish should be removed daily from tanks and ponds, whereas sick fish should be separated or removed.

Other daily routines on the farm include regular (daily) cleaning of tanks. Furthermore, fish must be fed regularly according to a set plan and set ratios. This is important, since overfeeding leads to accumulation of excess feed at the bottom of tanks or ponds and thus affects the water quality detrimentally. Feed must also come from good sources that ensure good quality feed that is free from contamination. Feed should also be stored in a dry place to avoid moisture and fungal infestation.

If fish are sick, samples of the fish are sent to the Finnish Food Authority for diagnoses and a veterinarian follows up with the fish farm. Unauthorised drugs should not be used to treat fish. In Finland, relatively low quantities of antibiotics are used due to efforts focused on disease prevention and efficient vaccination. Fish health and welfare is controlled in the same way as other animals mentioned in section 8.4.4.

Daily routines on the fish farm should ensure that there is as little possibility to contaminate fish as possible. Thus, visits to the fish farm should be limited. Visitors should be provided, at the very least, with shoe covers to ensure they do not spread diseases on the fish farm. Equipment used on the fish farm, such as brushes, nets, etc. should be cleaned daily.

Waste disposal mechanisms should be in place to ensure that rats, vermin and birds are not attracted to the site, as they can be disease vectors, cause water quality problems or eat the fish feed. It is important that the processes on the fish farm are planned so that movement proceeds from the ‘dirty area’ of the process to the ‘clean area’, without criss-crossing. Visitors should always move from the ‘clean area’ to the ‘dirty area’.

8.5.3 Primary processing

Fish must be stunned immediately when brought onboard a vessel or harvested from a fish farming site, to avoid gaping, scale loss and bruising that occurs when fish thrash about on board the vessel. Gaping is caused by severe muscle contractions in fish due to an accumulation of lactic acid in muscle tissue because of struggling and thrashing.

Fish are then bled in clean, running water, to slow clotting, to prevent the temperature of the fish from rising and to maintain its colour. Bleeding is completed by gilling or making a deep throat cut while the fish is in water. It is also recommended that fish are gutted within a very short time-span after bleeding (10–20 min) to maintain shelf-life. Bleeding and gutting are often completed in a single step.

When fish are washed, the back of a spoon may be used to press the remaining blood from the veins. Slime should also be washed off the skin. Fish of different sizes, types (species) and qualities are processed in different ways and thus it is important to **sort** catches or harvests into groups with different physical properties, and to **grade** catches or harvests into groups by quality. All fish must be chilled using ice, chilled water or refrigerated water. Fish should not be dropped but lowered. At this stage, fish maybe sold to processors or to final consumers as chilled, fresh fish or may be packed into a variety of ways and transported either chilled or frozen to a secondary processing plant.

8.5.4 Hygiene and sanitation on board a fishing or harvesting vessels or at a fish farm

It is important to frequently clean decks, equipment and clothes. The deck should be hosed down after each fishing set and at the end of every day, decks should be scrubbed and cleaned with detergent and then rinsed. The same requirements are relevant for fish farms wherever harvesting is being done. All the surfaces where fish are dressed should be rinsed continuously and all the holds must be washed after every delivery of fish. Sanitation is also important in order to kill microbes.

Fishermen, fish farmers and workers on a fish farm must also take care of their personal hygiene. Cuts and sores should be covered and hands should be washed regularly to prevent the spread of contaminants and decrease illnesses. In addition, they should familiarise themselves with issues related to occupational safety and hygiene.

8.5.5 Secondary processing

The secondary processing of fish is conducted to add value to fish that have been processed at the primary stage and involves making different cuts or splitting fish. Once fish arrive at the processing plant, they undergo a simple sensory observation with quality markers as described in Table 7.

Table 7. Quality markers for fresh fish

Class	Description
5 / Excellent	Gills are dark, red and have thin, clear slime. Eyes are bright, metallic and convex with clear pupils. The body has natural colours, firm scales and little or no slime. Fish are firm or in rigor.
4 / Good	Gills are red in colour and have some slime but still thin and clear. Eyes are bright, metallic, slightly cloudy pupils and slightly convex. The body has natural colours, firm scales and some slime. Fish are firm.
3 / Average	Gills are red-brown in colour, have some thick slime and have a 'warm' smell. Eyes are dull, with cloudy pupils and flat. Body may have a loose scales and thick slime.
2 / Poor	Gills are brown in colour and have a lot of slime and a slightly 'off' smell. Eyes are dull, pupils are cloudy, slightly concave and bloody. The body is missing scales, has dry skin and a lot of slime. The fish are soft to the touch.
1 / Very poor	Gills are brown in colour and have a lot of slime and smell of ammonia. Eyes are dull, pupils are concave or bulging out with blood. The body has few scales, dry skins and a lot of slime. The fish are very soft to the touch.

Secondary processing methods include salting, drying, smoking and canning. There are a wide variety of techniques used to complete these methods varying from one factory to another, one country to another and from one culture to another. HACCP principles are followed throughout the processing plant (see Chapter 2.)
However, the most important issue to remember when conducting secondary processing is that one should work as quickly as possible, fish should be kept as cool as possible and handled carefully.

Sampling for microbial pathogens is done throughout the process at certain predetermined critical points and sent to diagnostic laboratories. *Salmonella* spp and *Listeria* spp are monitored closely at fish processing plants. Water quality here is also monitored closely and water used should be of potable quality.

Packaging is an important step of secondary processing. Packaging of course depends on the processed product and its characteristics. In general, the packaging selected should work to maintain and extend the product shelf-life as much as possible. Traceability is accounted for by batch numbers on products, helping to identify the product all the way back to the farm, vessel or fisherman.

8.6 A case example of the berry product value chain in Finland

One-third of horticultural farms in Finland are berry farms with outdoor berry production, strawberries being one of the most widely grown berries in Finland. In addition to cultivated berries, Finland also has an abundance of wild berries. There are an estimated 50 varieties of wild berries in Finland, of which 30 are edible. The best known and commercially most valuable berries are lingonberries, crowberries, bilberries, cloudberries, raspberries, cranberries and sea buckthorn, which amount to an estimated 500 million kg per annum.

8.6.1 On the berry farm

Certified quality operations are followed to ensure product safety and minimal environmental load. A berry farmer must carefully select the sites where planting takes place. Slopes where snow cover accumulates in the winter are preferred to flatland, where waterlogging can occur.

However, steep slopes are not suitable since they are difficult to cultivate, and movement with agricultural machinery is difficult. It is also important that the soil is suitable for the berry variety selected for cultivation.

Soil should also be free of larger stones, which may interfere with the growth of berries and, in the worst-case scenario, also interfere with soil temperature as they collect heat during the day and give it off during the night. A soil analysis is also necessary to determine the type of operations that must be undertaken on the farm.

Weeding is an important operation on the berry farm for reducing the competition for nutrients and the interference of weeds with the growth of berries. Weeds may also cause problems during harvesting and can spread pests and diseases. In conventional farming, the use of certain authorised pesticides and herbicides are permitted but dosages are carefully defined and documented. Many farmers also use biological pest control.

Soil fertilisation and manuring are also conducted when needed. Before manuring, it is important to analyse the content of the manure in order to ensure that the right amounts of manure are spread onto the field. Sometimes it may be necessary to lime the soil, depending on the soil type and soil pH. In organic farming, it is important to check with the Finnish Food Authority to see what practices are permitted for the organic status of the crop.

It is important to use strawberry varieties that are both well-adapted to the harsh Finnish climatic conditions and that can tolerate diseases. Research institutions such as the Natural Research Institute of Finland, Luke, and universities work closely with farmers to develop varieties that can withstand the Finnish winter and that give a reliable and good, steady yield, as well as tasty berries. At the University of Eastern Finland, for instance, the closed nutrient cycle in vertical farming and LED lighting in berry farming is being investigated for greenhouse production. Although berry farmers are allowed to import seedlings from Central Europe, Luke also provides farmers with strawberry seedlings that are clean and free of diseases and pests.

Planting is done using tractors to ensure even spacing of seedlings. Following this, mulching is done to mitigate the growth of weeds. Mulch may be plastic or organic. If organic mulch is used, it is usually from straw or grass. Plastic mulch is better for strawberries since organic mulch easily results in mould growth on strawberries.

Water is an important factor for the cultivation of plants, and berries are no exception. Water is needed for growth, but it must not be stagnant, and farmers should ensure good water drainage, otherwise the berries are also at risk of fungal infestation. Surface waters are well-suited for watering plants but if necessary, water from boreholes and wells can be used, although it should reach ambient temperature before being used. It should be noted that surface waters that have an abundant algal bloom may clog water filters and nozzles.

Spray watering or drip watering may be done, depending on the variety of berry and the requirement for watering. Drip watering is preferred as it reduces fungal infections. If watering is done in a manner that results in the berries getting wet, the microbiological quality of the water must be tested to ensure that the berries do not get contaminated.

Berry pickers are trained by farmers to work hygienically and also pick berries carefully to ensure they are as intact as possible and free from defects and damage. After picking, berries are weighed and batches marked. Following this, berries are either delivered to buyers or collection points without delay or chilled and refrigerated and delivered within 24 hours. Berries may go directly to consumer markets or then to berry processing companies.

8.6.2 Berry processing

Berries are received at berry processing companies on loading platforms where visual checks are conducted to investigate the external quality, and the batch is registered into a database. Berries are then industrially frozen for processing later into jam, yoghurt, ice cream or simply packed as frozen. Batch identification numbers on packages help to trace the product all the way back to the farm from which the berries were picked.

8.7 Finnish value-added in the food sector

Attention to breeding, feeding, animal health, water, product development, well-developed and implemented legislation, where the stakeholders in the food value chain have collaborated effectively, has resulted in a high level of safety and quality of the products on the consumer market. The collaboration and trust between the different stakeholders ensure that there is open and timely communication and an aligned vision.

Digitalisation has been integral to the development of the management of safety, quality and traceability processes. However, in regions where the resources for this are limited or for very small companies and informal food business globally, the most important issue is to document the processes properly.

The Finnish food sector is also unique in the sense that farmers have collaborated to form cooperatives as well as their own processing companies. Thus, for instance, Finland's largest dairy company Valio is actually owned by farmers' cooperatives. This way, a specific dairy is bound, through contracts, to buy milk from cooperative farmers, but also, in turn, imposes specific requirements on the quality of their milk. Farmers have to carefully observe these to meet the quality requirements and to achieve a specific agreed price for their milk. A similar arrangement exists in the beef and berry production sectors.

The producer cooperatives and the processors also provide training to farmers as well as advisory services and other sector-related events. There is a high level of interdependency between the different stakeholders.

The food industry also collaborates closely with other actors such as education and research institutions on developing education and training. Research, development and innovation (RDI) can be done in research laboratories at universities and universities of applied sciences, for example.

Typical areas of collaboration include sensory evaluation or consumer testing of products, product development, not to mention safety and quality improvement pilot projects. The food industry also provides internships to students and participates in different corporate social responsibility activities.

The food industry is also very well connected to different sector-specific bodies and lobbies to advance its development. Different regional networks are also formed to advance the food sector in specific regions. For instance, the EU-funded Food Valley project at Savonia University of Applied Sciences and the University of Eastern Finland is an innovation ecosystem that brings together food sector experts, municipalities, development companies, food business, education and research stakeholders in the Savo region of Finland to create synergies, enhance co-creation, and strengthen local know-how in the food value chain.

9 The training of food safety and quality professionals in Finland

Education is a key factor in ensuring food safety and good quality food. All the actors in the food chain must have proper, and preferably formal training in hygienic practices and principles of safety and quality. This includes primary producers, food processing and trade, and the actual food inspection and analysis.

Accordingly, food safety is an essential aspect of the training of food professionals at all educational levels, from vocational institutes to the highest academic studies. This ensures that all the actors are able to implement the necessary food safety measures and – very importantly – are able to communicate with each other. This ensures that a high quality of food is maintained throughout the whole food value chain.

9.1 The role of food safety and quality specialists in society

Safety and quality permeate the whole food value chain, from farm to fork. This means that all professionals that are involved in food production, processing and marketing are expected to know the basics of food safety and quality and be committed to ensure its implementation in their respective tasks and roles. The present emphasis on self-monitoring and HACCP principles makes the appropriate training of all actors in the food chain even more important.

The other aspect of food safety is the official food control by authorities, and this requires special expertise both in legislative and administrative aspects and in food analysis. Accordingly, food safety and quality education is not limited to academic professionals, but is incorporated in the education and training of all the actors, from primary producers to specialists responsible for the actual food control. Food safety and quality measures are verifiable through food safety and quality management systems.

Managing food safety and quality requires the commitment of all the actors along the food chain from farm to fork. Educated and knowledgeable personnel are thus a key factor in the establishment of safety. Primary producers, who increasingly have at least a vocational qualification, must be able to communicate and understand the instructions, guidance and specific demands from veterinarians and municipal health inspectors.

Food processors, both at the managerial and the factory floor level, must understand the principles of hygiene and quality, in order to establish proper self-monitoring plans and implement the HACCP principles.

Regarding food analysis, there must be skilled laboratory personnel both at the managerial and expert roles (graduates from universities or universities of applied sciences) and at the technical level (qualification from vocational institutions).

9.2 The education system in Finland

The general principles of the Finnish education system are outlined in Figure 9. The system is based on compulsory comprehensive education lasting nine years, after which students can choose to proceed to either a high school (general upper secondary school) or a vocational institution.

After completing high school, students can enter university and do bachelor's and master's level studies, and eventually even start postgraduate studies to achieve a licentiate or doctorate degree. Alternatively, one can enter university of applied sciences education (also polytechnic), where one can do a polytechnic bachelor's degree. A master's degree at a university of applied sciences requires work experience prior to starting the programme.

It should be noted that the system is designed to avoid educational *cul-de-sac* situations, and – as can be seen in Figure 9 – there are several options and variations within the general educational route briefly described above. Thus, a motivated student who has not completed high school can eventually enter university and reach the highest academic degrees by taking advantage of the alternative educational routes. All students in Finland are encouraged to educate themselves to at least have some professional qualification.

9.3 The role of comprehensive schools and upper secondary schools

At comprehensive school, pupils learn the basics of health care, hygiene and natural sciences. Although compulsory education ends at the end of comprehensive school, most students continue their studies either to upper secondary school or to vocational institutions[13].

Upper secondary school prepares students for higher education at either universities or universities of applied sciences. Courses in biological sciences, mathematics, chemistry and physics are, accordingly, more theoretical and focus on the basic concepts of these sciences. Modern languages are also emphasised.

Students have to pass a national matriculation exam in order to successfully graduate. Upper secondary school does not give any professional qualifications but is considered a preparatory phase for advanced studies.

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[13] The Finnish government programme has resolved to increase compulsory education to the age of 18 and to have students gain an upper secondary or vocational school qualification.

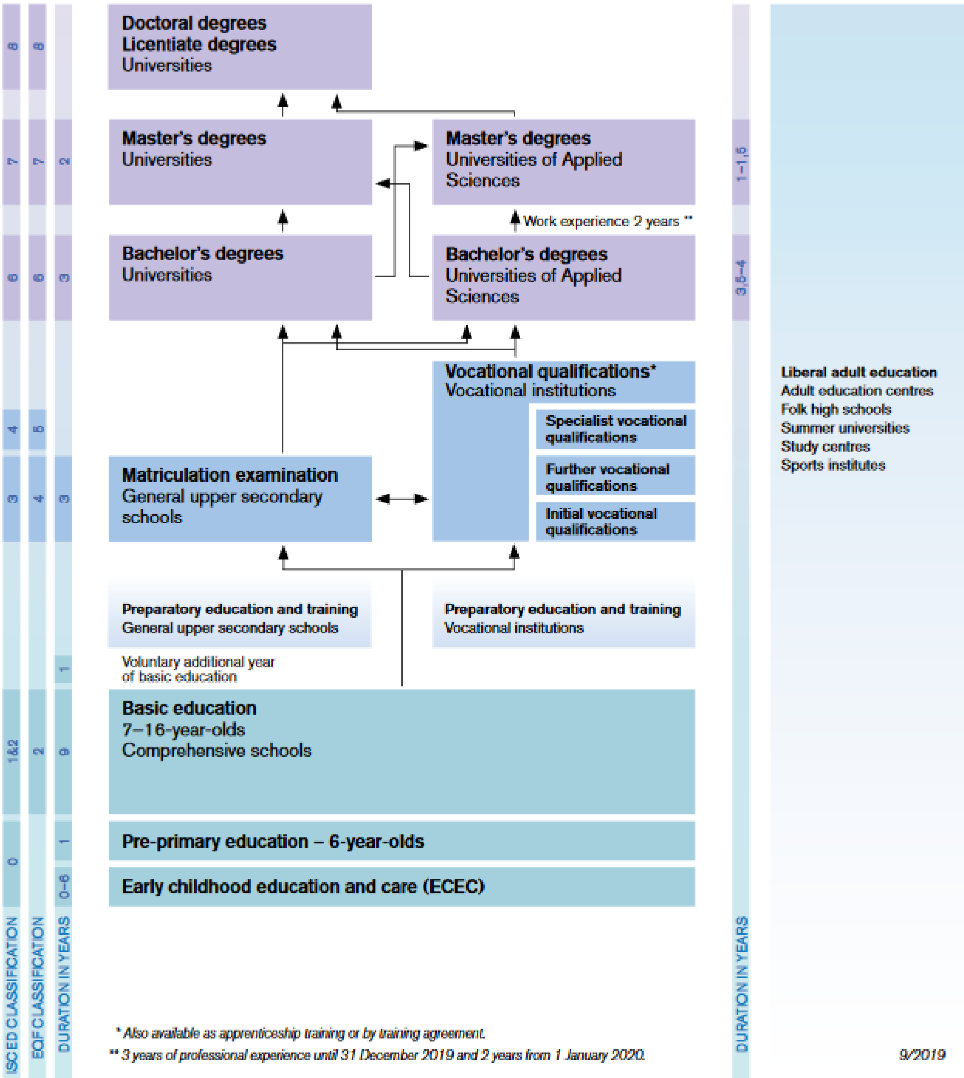

Figure 9. The education system in Finland[14]

[14] Ministry of Education and Culture of Finland, 2019

9.4 Vocational institutions

Vocational institutions give students the professional competence to work at the technical or clerical level in most industries, commerce or administration. Students typically enter study programmes after completing the comprehensive school or upper secondary school.

A vocational qualification typically takes up to three years (150 or 120 ECTS[15]). A vocational qualification in food-related fields allows students to specialise in food technology, bakery, meat or fish processing or dairy technology. According to the official requirements, a student should have the following competencies upon completing the programme:

'*Qualification holders adhere to the quality- and hygienic requirements related to food, prepare, pack and store products such as foods, sweets and beverages, bakery products, meat products and dairy products, follow and control the food manufacturing processes and operate the machinery. They act reliably, responsibly and show initiative by being a constructive member of their work environment and are willing to serve customers. Qualification holders take responsibility for their own work, self-evaluate their performance and develop their professional skills*.'

These requirements emphasise the independent role of the qualified worker and his/her responsibility in maintaining the quality and safety of both the processes and the final products.

In addition to actual food handlers, laboratory technicians, who have a crucial role in food analysis and control, are also educated in vocational institutions. During training, students learn the basics of mathematics and natural sciences, especially chemistry, biochemistry, physics and microbiology, and learn the fundamentals of analytical chemistry, instrumental analysis and microbiological methods. These compulsory studies comprise 145 ECTS, while the rest of the curriculum includes optional courses (30 ECTS), which give the students an opportunity to specialise in certain fields (bioanalytics, food analytics, industrial processes, etc.) Students typically finish their studies in a project, during which they engage in an internship in some industrial, educational or public laboratory to learn some special methodology. At

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[15] The ECTS (European Credit Transfer and Accumulation System) is a system used to measure workload of students. In Finland 1 ECTS is equivalent to 27 hours of work).

the end of this period, they have to demonstrate the skills acquired, and their performance is evaluated by the teacher together with a representative of the laboratory in which the training took place. This training/evaluation period gives the student an opportunity to specialise, for example, in food analysis.

Certain vocational institutions also award qualifications in agriculture, with opportunities to specialise in plant production, animal husbandry and horticulture. The principles of good agricultural practices, animal welfare and high quality of production are emphasised in the curricula.

Nowadays, approximately 45% of farmers have vocational qualifications in agriculture. One may also gain a qualification through work experience, with the qualification being a practitioner expert, and the Practitioner Experts' Association also provides training to these practitioner experts. Examples of vocational qualifications are shown in Table 8.

Table 8. Food sector vocational qualifications

Qualification	Credits	Expertise areas	Qualification name
Food sector basic vocational qualification	180 ECTS	Food biotechnology Bakery industry Meat industry Dairy industry	Food product manufacturer Baker-Confectioner Meat product manufacturer Dairy product manufacturer
Food processing vocational qualification	120 ECTS	Alcoholic beverage production Meat industry Dairy industry	No qualification name*
Food industry vocational qualification	120 ECTS	Food industry Meat industry Dairy industry	No qualification name*
Food industry specialised vocational qualification	180 ECTS	No focus areas	No qualification name*

*After graduation the employer decides on the title/position

9.5 Universities of applied sciences (polytechnics)

Universities of applied sciences are academic institutions, but they differ from research universities due to their more applied approach. Their study programmes typically aim at certain well-defined professions. Students at universities of applied sciences have either completed upper secondary school or have qualifications from a vocational institution. After 3.5–4.5 years of study the student can obtain a bachelor's degree (equivalent to 210–270 ECTS).

After gaining at least three years of professional experience, a bachelor's degree holder can enter a master's programme, which usually takes 1.5–3 years. Masters' degree graduates from a university of applied sciences are considered equal to masters' degree graduates from universities.

There are 24 universities of applied sciences in Finland, and at two of them, Seinäjoki University of Applied Sciences and Häme University of Applied Sciences, there is the possibility to specialise in actual food technology, whereas several others[16] offer programmes in catering and restaurant management, agrology, business management and entrepreneurship.

The bachelor's degree studies in food technology consists of basic studies giving the necessary scientific and methodological background and language skills, professional studies, optional studies and a training period (typically five months). The thesis project (15 ECTS) is typically done in close collaboration with industries and is thus very practically oriented. Quality, hygiene, safety and self-monitoring are consistently emphasised throughout the professional studies.

The master's studies focus on the development and understanding of the food chain, and the thesis project (30 ECTS) comprises half of the master programme. While the curricula on catering and restaurant management do not directly touch on food processing, safety and hygienic practices are, naturally, also emphasised in these studies.

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[16] Metropolia University of Applied Sciences, Savonia University of Applied Sciences and Turku University of Applied Sciences

In several universities of applied sciences, the students can also graduate in agriculture, with an official professional title of Agrologist. The emphasis is on the understanding of the food chain (from farm to fork), animal welfare and environmental management. Since farms are nowadays considered enterprises, entrepreneurial skills also have a prominent role in the curriculum.

9.6 Universities

There are 13 universities[17] in Finland, and at three of them (University of Eastern Finland, University of Helsinki and University of Turku) there is a possibility to study food sciences and/or nutrition. The general scheme of university studies (not applicable to medical and veterinary studies) is based on bachelor studies of 180 ECTS followed by master's studies (120 ECTS), with the whole process theoretically taking approximately five years.

At the University of Helsinki, food technology is the major subject in the Food Sciences programme at the Faculty of Agriculture and Forestry, whereas at the University of Turku, the Faculty of Science and Engineering has two majors, food chemistry and food development. At the University of Eastern Finland, the Institute of Public Health and Clinical Nutrition offer food quality and product development modules as part of the Nutrition Programme, where it is also possible to specialise in nutrition and gain a nutrition therapist qualification.

Food safety and hygiene are essential parts of the curricula at all these universities, but in the Faculty of Veterinary Medicine at the University of Helsinki there is the possibility to actually specialise in food safety and hygiene at the Department of Food Hygiene and Environmental Health. This is partly because of historical reasons, as veterinarians traditionally bear the responsibility for official food control in Finland.

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[17] Aalto University, University of Helsinki, University of Eastern Finland, University of Jyväskylä, University of Lapland, Lappeenranta University of Technology, University of Oulu, Hanken School of Economics, University of the Arts Helsinki, Tampere University, University of Turku, University of Vaasa and Åbo Akademi University.

The Faculty of Agriculture and Forestry of the University of Helsinki is also the only place that offers university-level agricultural education in Finland. Animal health and welfare, along with the production parameters, are central aspects in production animal science, while the Faculty of Veterinary Medicine focuses on the diagnostics, treatment and prevention of animal diseases.

REFERENCES

European Food Safety Authority, 2020. EFA Scientific Committee and Panels [online] available at: www.efsa.eu accessed 23.08.2020

European Food Safety Authority, 2019. Eurobarometer on Food Safety in the EU 2019 [online] available at: https://www.efsa.europa.eu/en/corporate/pub/eurobarometer19 accessed 23.08.2020

Eurostat, 2020. Population and Population Change Statistics in Europe [online] available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_and_population_change_statistics accessed 23.08.2020

Eurostat, 2019. European Farm Statistics

FAO, 2020. The State of World Fisheries and Aquaculture 2020 [online] available at: http://www.fao.org/state-of-fisheries-aquaculture accessed 23.08.2020

FAO, 2019. World Food Safety Day, 2019. Call to Action [online] available at: http://www.fao.org/fao-who-codexalimentarius/world-food-safety-day/calls-to-action/en/ accessed 23.08.2020

Finnish Food Authority, 2020. Oiva [online] available at: https://www.oivahymy.fi/en/front-page/ accessed 23.08.2020

Ministry of Education and Culture of Finland, 2019. The Finnish Education System [online] available at: https://minedu.fi/en/education-system accessed 23.08.2020

Natural Resources Institute, Finland, 2018[a]. Finnish Farm statistics [online] available at: https://stat.luke.fi accessed 23.08.2020

Natural Resources Institute, Finland. 2018[b]. E-yearbook of Food and Natural Resource Statistics for 2018 [online] available at: https://stat.luke.fi/sites/default/files/luke-luobio_30_2019.pdf accessed 23.08.2020

Natural Resources Institute, Finland, 2018[c]. Fish Consumption 2018 [online] available at: https://stat.luke.fi/en/fish-consumption accessed 23.08.2020

Statistics Finland, 2018. Finnish Farm Statistics [online] available at: https://www.stat.fi accessed 23.08.2020

UNESCO, 2017. The United Nations World Water Development Report, Wastewater: The Untapped Resource [online] available at: http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/2017-wastewater-the-untapped-resource/ accessed 23.08.2020

World Health Organisation, 2015. WHO Estimates of the Global Burden of Foodborne Diseases [online] available at: https://www.who.int/activities/estimating-the-burden-of-foodborne-diseases accessed 23.08.2020

ROSEANNA AVENTO AND ATTE VON WRIGHT

This guide shares Finnish practices on food safety and quality management, based on EU legislation and characterised by open, transparent collaboration between all the stakeholders in any given food value chain. The roles of education and of different actors in managing food safety and quality, across the food value chain, are presented. The aim is to inspire and encourage food sector experts to create their own innovative solutions to ensure access to safe, healthy and nutritious foods.

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