Chapter

Managing Food Safety and Safeguarding Consumer Health: Strategies for Ensuring Food Protection from Farm to Fork

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Abstract

Food safety ensures that food is prepared and consumed for its intended purpose without causing harm to consumers. In addition, food security ensures that all individuals have consistent access to a safe and nutritious food supply, enabling them to maintain good health and an active lifestyle. The farm-to-table food chain involves various processes to ensure that the food on consumers' plates is safe and nutritious. This process is multifaceted, beginning with the seed and ending with the final meal. It involves numerous stakeholders, including farmers, processors, transporters, retailers, and consumers, each playing a critical role in maintaining food safety. The consumption of unsafe food contributes to foodborne diseases, causing millions of cases and deaths worldwide each year. Contaminants can enter the food supply chain at any point, leading to foodborne illnesses that affect millions of people annually. Therefore, it is essential to recognize the impact of supply chain management on food safety. This chapter discusses the strategies applied at each stage of the food chain to ensure food safety from farm to fork.

Keywords: food safety, food security, food protection, consumer health, farm-to-fork

1. Introduction

The provision of unsafe food poses significant risks, potentially leading to foodborne illnesses and legal implications for the food industry. These persistent problems require additional strategies to minimize and eliminate such risks. Food safety is a shared responsibility among stakeholders, requiring communication and the raising of awareness about potential hazards throughout the food chain [1, 2]. The responsibility of health authorities in South Africa is to ensure that consumers are not exposed to food that causes harm. This is known as "Food Safety Control" and is a mandatory regulatory activity of enforcement by the relevant health authorities [3]. Consumer protection must be ensured, and all foods must be kept safe during production, harvesting, processing, distribution, retailing, consumption, and even food waste

handling. Food must be suitable for human consumption and conform to the requirements of the World Health Organization and food safety laws [4].

The South African government has passed legislation to ensure that all food products and food-handling facilities comply with health standards, protecting consumers from unsafe food and unhygienic conditions. Some examples of this legislation include the Agricultural Products Standards Act (Act No. 119 of 1990); Animal Diseases Act (Act No. 35 of 1984); Animal Identification Act (Act No. 6 of 2002); Animal Improvement Act (Act. No. 62 of 1998); Animal Protection Act (Act No. 71 of 1962); Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (Act No. 36 of 1947); Meat Safety Act (Act No. 40 of 2000); Performing Animals Protection Act (Act No. 24 of 1935); Veterinary and Para-Veterinary Professions Act (Act No. 19 of 1982); Liquor Products Act (Act 60 of 1989); Guidelines for an Environmental Health Officer (EHO) Engaged in the Evaluation of Food Premises within the Hazard Analysis Critical Control Point (HACCP) Principles (Act 107 of 1996); and the National Health Act (Act No. 61 of 2003). Consequently, the South African food industry is well established and well positioned to protect consumers.

Ensuring food safety begins with agriculture. Good agricultural practices (GAPs) are critical in food safety and encompass a variety of farming methods that prioritize the safety and health of both produce and the environment. This includes choosing disease-resistant seeds, implementing appropriate soil management practices, and using safe water for irrigation [5]. These practices are designed to increase crop yields and minimize the risk of contamination by pathogens, chemicals, and other hazardous agents.

Food safety is a multifaceted process that begins with the seed and culminates in the final meal. It involves numerous stakeholders, including farmers, processors, distributors, retailers, and consumers (**Figure 1**) [6]. Each stakeholder plays a critical role in maintaining food integrity and safety.

Figure 1.
Food chain processes from farm to table. Source: Adapted from Moreira-Dantas et al. ([6], p. 5).

2. Safeguarding food during production on the farm

It is essential to ensure food safety at every step of the food chain, as many potential food safety risks can arise from the farm where food is grown to the table where it is consumed. These risks arise from environmental contamination, improper handling and storage, and even intentional contamination [2]. Therefore, it is crucial to identify and assess food safety risks on the farm and take appropriate measures to mitigate them. Four food safety risks are likely to arise on the farm.

Chemical excess and pesticides: Produce must be protected from pests and diseases using pesticides and chemicals. These substances must be used properly to prevent harmful deposits that cause food health problems [7].

Microbial contamination: Bacteria, viruses, and other microorganisms can also contaminate food crops and produce on the farm.

Allergens: Many people are allergic to nuts, dairy, or gluten. Therefore, these allergens must be properly labeled to prevent allergic reactions when consumed [8].

Intentional contamination: Intentional contamination involves the deliberate use of chemicals or biological agents to compromise food safety. Robust food safety regulations and guidelines must be developed and implemented to address these food safety risks. These guidelines must cover all steps in the food chain (from production to consumption) and should be reviewed and updated regularly to reflect new technologies and risks. Working together, all stakeholders in the food chain can contribute to ensuring the safety of the food that reaches consumers [9].

2.1 Good agricultural practices (GAPs)

Ensuring food safety is one of the crucial aspects of Good Agricultural Practices (GAPs). Farmers and producers are guided by these standards to ensure the safety and quality of their products. GAPs help minimize the risk of contamination by harmful bacteria, pesticides, and other hazardous substances.

The following are essential elements of GAPs for ensuring food safety:

Site selection and preparation: Selecting a suitable farming location and preparing the land for cultivation are crucial steps. This includes ensuring that the soil is suitable for growing crops and that there are no sources of contamination that could potentially affect food safety.

Water management: Farmers and producers must use clean and safe water for irrigation, crop spraying, and agricultural practices. The quality and safety of water are critical for maintaining food safety.

Pest control: Proper pest control is necessary to prevent the spread of diseases and crop contamination. Integrated pest management (IPM) practices, which utilize safe and effective pest control methods, are an essential part of this process.

Harvesting and post-harvest handling: After harvesting, crops must be safeguarded to ensure they remain safe and free from contamination. This includes proper storage, cooling, and transport [10].

2.2 Good hygiene practices (GHPs)

Good Hygienic Practices (GHPs) are essential for ensuring the safety and quality of food products throughout the supply chain. Proper implementation of hygiene is crucial at every stage of the chain.

GHP requirements at the farm: On the farm, GHPs comprise proper sanitation practices, such as adequate storage facilities for inputs, clean water sources, and regular equipment and tool disinfection. Personal protective equipment (PPE) must be used to prevent livestock and crop contamination. Furthermore, farmers must be trained in GHPs to understand food handler-related risks and how to mitigate them.

GHPs during transportation: Food must be properly packaged and stored to prevent contamination and spoilage during transport. Vehicles transporting food must be frequently cleaned and disinfected, and drivers must be trained in proper food handling and storage practices. Vehicle temperature must be controlled and maintained to prevent the growth of harmful bacteria.

Processing and manufacturing GHPs on the farm: Some food items, such as grains, are processed on farms. Therefore, farmers must adhere to GHP sanitation protocols, including regular cleaning of equipment and facility disinfection. Also, employees must be trained in proper hygiene practices and wear appropriate PPE. Hazard Analysis and Critical Control Point (HACCP) systems must be implemented to identify and address potential hazards in the production process.

Food safety and quality can be ensured by implementing the GHPs throughout the supply chain. By adopting proper hygiene practices from the farm to the table, farmers can prevent foodborne illnesses and ensure consumers receive nutritious and safe food [11].

2.3 Hazard analysis and critical control point (HACCP)

The Hazard Analysis and Critical Control Point (HACCP) management method is a preventive, systematic approach to identify and prevent possible hazards in the food chain. It is widely used in the food industry to ensure safe and good quality food production and consumption. HACCP incorporates the steps of the food chain from production to processing, distribution, and household preparation. Stakeholders at each stage must identify potential hazards, analyze the risks associated with those hazards, and implement control measures to prevent them.

The HACCP system has seven key principles that provide a structured framework for recognizing and controlling hazards in the food production chain: conducting hazard analysis, identifying critical control points (CCPs), creating critical limits, implementing control measures, checking the system, creating corrective actions, and implementing authentication procedures [12].

3. Safeguarding food safety in the processing stage of the food chain

The processing stage of the food chain occurs post-harvest, where different harvested farm products are cleaned and packaged. Also, according to the Foodstuffs, Cosmetics, and Disinfectants Act of 1972, the food must be properly labeled before being distributed to retailers, stores, and markets [13].

3.1 Protection of vegetables and fruits during cleaning and packaging

Fruits and vegetables must be thoroughly washed and packaged after harvest and before they are transferred to retailers and stores. Some produce is sent to factories for further processing. Therefore, farm produce must be carefully cleaned using

appropriate cleaning agents. This process is important for removing leftover soil, chemicals, and pathogens from the surface of the produce [14]. Proper washing and rinsing with running water help to eliminate pathogens that might remain on the surface. It also helps remove dirt, bacteria, stubborn garden pests, and residual pesticides [15], ensuring that the produce is fresh and free from contaminants. These activities must adhere to the standards of cleanliness and freshness, as outlined in Current Good Manufacturing Practices (CGMPs) [14].

After washing, fruits and vegetables may be cut, dried, smoked, fermented, or left in their original condition, depending on the desired final food product. Food must be packaged in cans, jars, or plastic wraps. Proper packaging prevents pathogens from entering and contaminating food products. Whole fruits and vegetables intended for bulk sale should be placed in appropriate boxes [14].

3.2 Protection of poultry and poultry products during processing and packaging

Poultry processing involves preparing meat from various poultry types for human consumption. This involves deboning, trimming, and cutting birds into parts using sharp-bladed tools, as well as marinating, spicing, and seasoning to improve meat quality. Secondary processing may also be performed, such as converting chicken parts into ready-to-eat products such as hamburger patties, sausages, nuggets, and polonies.

The following steps, as recommended by [16], are important to ensuring safe and hygienic poultry processing for human consumption:

Receiving: Upon arrival at the processing plant, poultry crates must be transferred to the shackling area by conveyors and placed in holding cages or modular bins. This step ensures proper air circulation and prevents injuries to other birds.

Slaughtering: Slaughtering is often performed manually by cutting the throat at the ventrolateral base to rupture the jugular veins and carotid arteries, ensuring complete bleeding.

Scalding and de-feathering: Birds should be scalded in water at a temperature of 53°C for 2 to 3 minutes. Proper scalding prevents over- or under-scalding, ensuring the outer skin and feathers are fully and effortlessly separated. Poultry pickers remove loose feathers during scalding, and poultry carcasses are passed over a flame to remove filoplumes.

Evisceration: During evisceration, meat examiners perform detailed visual checks for bruising, fecal matter, and illnesses. Intestines must be discarded, while gizzards and livers are kept, cut open, and cleaned. The head is removed manually or with a V-shaped knife, and the trachea, esophagus, lungs, and kidneys are removed by hand.

Cleaning and washing of poultry carcasses: Poultry carcasses must be sprayed with cold water to remove blood, miscellaneous flesh, and other foreign substances to minimize contamination.

Poultry carcass chilling: A rapid cooldown of less than 40 minutes is necessary to inhibit microbial growth and maximize the shelf life of poultry carcasses.

Packaging of poultry carcasses: Carcasses are assessed and cut into desired portions. These parts are packaged, sealed, and separated; giblets and legs are placed in individual trays. The final product is verified to meet customer expectations.

Freezing and preservation: Regular assessments are necessary to ensure consistency in processing procedures and prevent spoilage and deterioration caused by microbial growth and fat oxidation.

3.3 Protection of meat and meat products during processing and packaging

During meat processing, animals are slaughtered and meat is cut and inspected to ensure it is safe for human consumption. At this stage, meat is packaged, processed into various products, and delivered to stores for sale to customers.

Once meat arrives at the point of sale, handling and storage become vital to safeguarding its safety and quality. Strict measures must be in place to inspect, refrigerate, and store all meat and meat products. These practices are essential for minimizing the risk of foodborne illnesses. Inappropriate food handling and storage procedures can negatively impact both food service companies and their customers [17].

3.3.1 Meat receiving and storage procedures

The following guidelines, as suggested by [18], are important for ensuring proper inspection during meat receiving and storage:

The meat order must match the requisition regarding product names. Both the delivery person and the receiver must sign to confirm the order.

All packages must be sealed and free from damage upon receipt and during storage.

The temperature of the delivered meat must meet appropriate standards upon arrival at the receiving and storage areas.

All meat and meat products must be sorted and immediately moved to their designated storage areas.

To avoid cross-contamination, fish, meat, and poultry must be stored separately. Fish containers must remain sealed until they are ready to be used.

Cooler temperatures must be checked and recorded daily according to health department regulations. Cooler and freezer doors must be closed at all times. Any unusual temperature fluctuations must be reported immediately to the employer.

3.3.2 Protecting meat and meat products during storage

According to [19], the following actions must be taken to ensure that meat and meat products are stored safely:

Meat must be properly packaged to prevent drying out, spoilage, and freezer burns. Whole subprimal cuts should be vacuum-packed immediately after being removed from the animal carcass to prolong shelf life.

For retail purposes, meat should be portioned and either wrapped in absorbent layers on trays or vacuum-packed.

Meat and meat products intended for food service can be vacuum-packed or stored in food-grade containers following food safety standards.

Meat must be vacuum-packed or tightly wrapped in freezer paper and stored in a freezer to prevent freezer burns.

To maintain flavor and moisture, meat should be stored at temperatures between 0 and 2°C.

All food containers and boxes should be raised above floor level to allow cool air circulation by coils and fans.

Meat coolers should be maintained at a humidity level of 75 to 80% to prevent meat contraction and minimize favorable conditions for bacterial growth.

Meat freezers should be kept at temperatures ranging from −23 to −29°C (−10 to −20°F).

3.3.3 Protecting meat and meat products during processing

Once processing begins, the following precautions must be taken to reduce any additional contamination of meat and meat products:

Boxes and containers must not be placed on cutting boards, work surfaces, or floors. Cutting boards and meat processing tables must be cleaned and sanitized before use. As most sanitizers can be toxic when wet, work surfaces must be free from residue.

Separate cutting boards must be designated for different meat species, such as chicken, pork, and fish, and an additional board must be reserved exclusively for cutting cooked meat. After use, cutting boards should be promptly cleaned, sanitized, and elevated to dry.

Meat tenderizers and slicers must be cleaned and sanitized after each use, particularly when switching between different meat species or between cooked and raw products. If feasible, different meat species and cooked and raw products should be processed on separate days to minimize cross-contamination.

High-quality oxygen and water vapor barrier packaging materials are recommended. Such materials should create a close-fitting cover over the meat and provide barriers against oil, oxygen, aroma, flavor, gas, light, and moisture. For example, polyvinylidene chloride (PVDC) is an effective option for tight-fitting over-wraps [18].

3.4 Safeguarding milk and milk products during processing and packaging

A healthy animal produces healthy and clean milk, making animal health a crucial consideration in milk production. Maintaining good hygiene and sanitation standards is essential for preventing bacterial contamination. Raw milk must be delivered to the dairy manufacturer as soon as possible after milking and the milk must be cooled to 4°C or lower, where it should remain until treated [20].

Several practices for safeguarding milk and milk products during production. Cattle must receive sufficient feed and clean drinking water before milking are recommended [21]. Dairy cattle should be bathed whenever possible. If bathing is not possible, the cattle must be cleaned using a broom or duster and kept healthy.

Milk from cattle under treatment must be discarded during the withdrawal treatment period. The udder and teats of dairy cattle must be washed with clean water and wiped with a clean, dry cloth. Teats should be cleaned after calves have finished nursing from the cattle.

The cow shed must be cleaned at least 15 minutes before milking to ensure a non-slippery surface for the cattle. The cattle should remain standing for at least 30 minutes after milking. Feed may be provided to encourage the cattle to stand.

The utensils used during milking must be stainless steel without sharp edges and must be thoroughly cleaned with detergent and hot water. They should be inverted to dry before use and covered with a tight-fitting lid. Utensils must be exclusively used for milking, cleaned and sanitized before and after each use, and kept dry.

Milk should be passed through a filter before storage to prevent contamination.

Milkers must wash their hands with soap, wear clean clothes, and avoid contact between milk and their body, clothing, or personal items. Smoking, chewing, spitting, and sneezing/coughing towards the udder or vessel during milking must be avoided. Milkers must be free of respiratory diseases, open wounds, and cuts.

To minimize flies, feed, dry cow dung cake, and other unnecessary substances, a separate container must be used to wash the cattle's udder and teats. After milking, the teats must be rinsed with a disinfected solution (with water or iodophor) to avoid post-milking infections [22].

3.4.1 Safeguarding milk on delivery to cooperative societies/milk collection centers

Milk collection involves several critical activities, including the receipt and testing of milk, local and sample milk sales, milk dispatch to the Milk Union, payment processes, and account management. Input services include animal health coverage, artificial insemination, cattle feed supply, provision of mineral mixtures and other feed supplements, distribution of fodder seeds, and extension services for producer members. These efforts promote the adoption of clean milk production practices.

To prevent milk contamination, milk should be transported in stainless steel utensils and cans. Milk producers must deliver milk to dairy cooperative societies (DCS) or milk collection centers (MCC) as soon as possible after milking to limit the multiplication of harmful bacteria [23].

3.4.2 Milk tank cleaning procedures

Milk tanks may be cleaned manually or with clean-in-place (CIP) methods.
Manual procedure for cleaning bulk milk tanks

1. *Pre-rinse*

   The tank must be manually rinsed, and the pipeline must be flushed with lukewarm water (38–43°C) immediately after use to remove any remaining milk residues.

   All tank parts, including the thermometer probe and dipstick, must be disassembled and set aside before executing routine tank cleaning.

2. *Detergent Wash*

   An alkaline cleaning solution (0.5–0.75%) containing basic alkali, phosphates, wetting agents, and chelating agents, as recommended by the manufacturer and based on water quality tests, is ideal for cleaning milk tanks.

   Disassembled tank parts must be soaked in the alkaline solution at 49–57°C for 5 minutes, brushed thoroughly, and drained.

3. *Clean-in-Place (CIP) of Bulk Milk Tanks*

   Milk tanks must be manually rinsed and the pipeline flushed with lukewarm water immediately after use to remove remaining milk residues.

A detergent solution (0.8–1.0%) must be circulated at 77°C for 6–10 minutes. The tank and all parts must be brushed and drained, and the outlet connection and outlet valve must be manually cleaned.

The detergent solution must be rinsed with tap water before acid rinsing and the tank must be rinsed inside and outside, including the valves.

Occasionally, a solution of nitric acid (55–60°C) can be used to rinse the tank and remove inorganic soils that accumulate over time. The solution must be circulated for 2 to 3 minutes before draining the tank. Parts of the tank, such as the line and receiver jar, must be visually inspected to ensure proper cleaning [24].

3.4.3 Safeguarding milk during transport from the dairy cooperative society (DCS) and receipt at the dairy plant

Milk is transferred from the dairy cooperative society (DCS) or milk collection center (MCC) to the dairy plant using cans or road milk tankers.

Upon arrival at the dairy plant, the quality of the milk must be assessed and recorded. The milk is then entered into a weighing system to measure the gross and net weights.

Milk can be delivered manually by lorry and transferred onto a conveyor belt, where it undergoes rapid sensory evaluation and preliminary tests to determine whether it should be accepted or rejected. Cans used for manual delivery must be placed on the conveyors for emptying.

Milk can also be delivered in automatic cans, where the lids are automatically removed and the milk is emptied into a weighing bowl. A drip saver is used to collect any remaining milk.

The weighing equipment must be well maintained and checked daily, with periodic calibrations performed by an external agency to ensure reliability.

After weighing, raw milk is pumped into storage tanks through an inline filter and milk chiller. Empty cans are directed to a can washer, where they are thoroughly cleaned with water and detergent using rotary and straight-through can washing machines. These machines effectively rinse, clean, and sterilize the containers [25].

3.4.4 Safeguarding milk during processing

3.4.4.1 Chilling of incoming milk

During transportation, milk must be kept at temperatures slightly above 4°C. Subsequently, before storing the milk in a silo tank, the milk must be cooled to below 4°C until processing begins.

3.4.5 Raw milk storage

Raw chilled milk, as received from the raw milk receiving dock (RMRD), must be stored in stainless steel tanks and silos constructed with polyurethane sheets of sufficient thickness to prevent temperature rise. Agitators must be mechanically sealed to prevent oil leakage into the milk. To keep the milk homogenous and cool it uniformly, the agitator must be positioned on top or leaning near the bottom [25].

3.4.6 Clarification of milk

All undesirable milk solids like dirt, dust, hay, manure, bacteria, somatic cells, and pulverized hair must be removed using centrifugal force. Centrifugal equipment can also remove bacterial spores and separate milk into cream and skimmed milk.

3.4.7 Milk standardization

The South Africa and India have established regulatory bodies (FSSAI in India and the National Department of Health in South Africa) to oversee food safety, including milk processing and dairy products. Therefore they have the same regulatory bodies to oversee milk processing and diary products [26].

3.4.8 Milk homogenization

Milk homogenization involves breaking down milkfat particles into smaller sizes using a high-pressure process to ensure uniform dispersion within the solution. Milk is forced through small holes under a pressure of 2500 PSI, while maintaining 500 PSI to prevent the formation of fat globule clumps.

3.4.9 Milk pasteurization

Milk pasteurization is the process of heating milk to a minimum temperature of 72°C to kill harmful bacteria that can cause infectious diseases such as listeriosis, typhoid fever, tuberculosis, diphtheria, and brucellosis. Milk is held at this temperature for 15 seconds and then rapidly cooled to below 4°C [27].

3.4.10 Milk packaging

Packaging serves multiple purposes, including carrying, identifying, protecting, and merchandising goods for storage, transportation, distribution, retailing, and use. After processing, milk is pumped to the packaging plant and packaged in various sizes for distribution to end users. Mechanical pouch-packing machines can be used instead of pneumatic machines.

Proper selection and utilization of containers are critical in ensuring a safe final product for consumers. Weight and nutritional labeling are essential components of milk packaging. The limited biological shelf life of organic milk must also be considered in the selection of packaging [21].

3.4.10.1 Safeguarding milk and milk products during packaging

Milk packaging material storerooms must be kept free from pests and dust, and they should be separated from storage areas containing substances that could contaminate the product. This minimizes the risks of product contamination.

Milk packaging materials must be stored off the floor and handled by experienced staff to avoid delays and contamination.

Heat-treated milk and milk products must be bottled or filled into containers mechanically and sealed immediately.

Wrapping and packaging for dairy products should not be recycled unless the containers are reusable. Reusable containers must be thoroughly cleaned and disinfected before reusing.

Sealing of milk containers should be performed at the same establishment where the milk is heated, treated, and processed. Sealing must occur immediately after filling to protect the milk from external contamination or adverse effects on its characteristics. The sealing mechanism must be designed to leave clear evidence if the container has been opened, ensuring tamper-proof packaging [21].

3.4.11 Safeguarding milk and milk products during crating, dispatch, and distribution

After packaging and labeling milk and its products, poly packs must be systematically arranged in plastic crates for transportation by trucks to different milk sales outlets.

High-quality, flexible crate washers must be used to effectively clean the crates before transporting milk pouches to the dairy plant. This reduces contamination risks and improves product quality, transportation, and storage.

A crate washer typically consists of a washing section(s) and a rising section. The washing section has nozzles mounted on spraying racks to deliver temperature-controlled and chemical-dosed water to wash the crates through mechanical action. The rinsing section uses fresh water to ensure thorough rinsing after washing. The washing compartments include reservoirs that allow for the reuse of washing water. Crates move through the machine on conveyor belts at a specified speed to ensure they are cleaned adequately based on the level of contamination [25].

3.5 Safeguarding fish and fish products during processing, packaging, and distribution

Fish are sensitive and prone to contamination; therefore, safeguarding fish during processing and handling is important to ensure that it is safe for human consumption, meets regulatory obligations, and has a long shelf life. Good hygiene practices are also recommended during packaging, distribution, storage, and final preparation for consumption.

Four primary procedures are utilized to enhance the shelf life of fish and fish products: heating, freezing, drying or adding chemicals, and irradiating. These methods extend the shelf life of fish and its products by inhibiting the mechanisms that promote spoilage and degradation [28].

3.5.1 Safeguarding fish and fish products during processing

Fish are delicate, and any divergences from GHPs during processing, handling, and storage can result in contamination, bacterial growth, and spoilage, posing health risks to customers. The food industry is responsible for safeguarding fish and fish products because it oversees processes ranging from handling unfrozen fillets to producing canned fish, fish meals, smoked fatty fish, and frozen fish.

The most important factors in ensuring safety in fish processing include time, temperature, contamination, damage or deterioration, hygiene and sanitation, equipment and methods, packaging, and proper portioning. The following best practices are recommended for safeguarding fish and fish products during handling:

Good Manufacturing Practices (GMPs): GMPs must be followed in fish processing. This involves regular cleaning and disinfection of processing equipment and facilities, proper storage of raw materials and finished products, and ensuring workers wear PPE.

Hazard Analysis and Critical Control Point (HACCP): The HACCP approach, endorsed by the Food and Agricultural Organization (FAO), identifies and controls potential hazards in fish processing. It includes performing hazard analysis, recognizing critical control points, creating essential limits, and monitoring and verifying the hazard control process. Every fish processing establishment must implement an HACCP plan to identify, monitor, and control hazards.

Traceability: Traceability tracks the movement of the fish product from the source to the final destination. It is important for recalling products in cases of contamination or quality problems. The globalization of the fish industry, regarding procurement, processing, and marketing, demands increased traceability, especially for fish products. This is due to the supply chain's length, which can impact quality and consumer safety.

Time and temperature control: Time and temperature control are critical to maintaining the quality and safety of fish and fish products. Therefore, the harvesting, storage, and distribution of fish must be safeguarded to prevent bacterial growth and decomposition.

Training and education: All workers who process and handle fish must be regularly trained in food safety, hygiene, and quality control. Training will guarantee that all workers acquire the necessary skills to identify potential hazards and prevent contamination. Additionally, whole fish and fish meal products used for animal food are eligible for inspection and certification [29].

3.6 Safeguarding the processing, packaging, and distribution of grains and grain products

Grain is used for human and animal consumption in natural and processed forms. Therefore, it is necessary to apply strict hygiene measures to ensure that grains do not become infested by insects. Additionally, there are health laws and regulations for controlling the handling, transportation, storage, and sale of grain products in South Africa. The law is ordered to protect society against food toxicity. In addition, the law provides guidelines within which the grain industry must function to protect it from civilian actions. There are different laws and control systems:

Standards for food hygiene and food safety as stipulated in 3(3)(a)(ii) of the Agricultural Product Standards Act No. 119 of 1990: This law proposes a critical control points analysis of risk. The HACCP system is commonly used in food production and processing companies across South Africa and is a globally acknowledged system. The system's focus is on identifying, controlling, and preventing hazards in establishments. Its seven principles, combined with preliminary procedures, result in twelve HACCP steps.

The Health Act 63 of 1977: This act regulates businesses' obligations for processing, preparing, and serving food.

South African Bureau of Standards: Good-practice codes provided by the South African Bureau of Standards guide businesses in handling, storing, and disposing of waste materials safely (SANS 10206). These standards require businesses to ensure the health and safety of workers working, particularly those working with hazardous substances. Businesses are required to maintain detailed records, including medical documentation for pesticide handling, incident or accident reports, and poison registers for pesticides classified as Groups 1a and 1b (including details such as name, batch number, dates, quantities, issues, balances, and uses).

Foodstuffs, Cosmetics and Disinfectants Act no. 54 (1972): This act provides guidelines for maximum residue limits (MRL) and poisonous seeds [30].

3.6.1 Control points for food hygiene of the equipment

It is important to maintain proper hygiene and cleanliness of equipment that comes into contact with raw grains. The following measures are recommended:

Mass buckets: The overhead cover structures of drains and ducts must be cleaned annually using high-pressure water pumps. Accumulated dust must be removed, and drainpipes and conduits must be kept clean and free from blockages.

Conveyor buckets: The cranks must turn freely, and spillages and dust accumulated at turning points must be cleaned daily.

Bucket elevators: Turning points must be free from any grain or dust and monitored and controlled daily.

Mass meters: All levers and drying blocks must be cleaned and free of oil or lubrication on latches. Any rat nests, animal droppings, dust, and grain must be removed.

Grain pre-cleaning and cleaning machines: All foreign objects must be removed from sieves, including blockages in screw feeders and flaps. All control valves in supply ducts and sieves must be cleaned, including bolts and nuts around sieves.

Compressor: Air filters must be cleaned weekly, and dust extraction equipment must be cleaned monthly.

Water bottles: Water bottles must be washed every 2 weeks with clean water and the automatic filter must be checked to ensure proper functioning.

Oil bottles: Oil bottles must be washed every 2 weeks with clean water to ensure the automatic emptier floater functions properly.

Pipe equipment: Pipe equipment must be properly tightened, with stop taps closed tightly and with no leakages in the pipe network.

Valves: Valves must be installed securely and tightly with locked limit switches and valve boxes.

Latches: Latches must be tightly closed and free from obstructions in the grooves. Side latches must be locked and the valve channels must move freely.

Ductwork: Bolts and nuts must be tightened, obstructions must be removed, watertight rubber inspection lids and overhangs must be cleaned, and peeling paint and leaks should be addressed [11].

3.6.2 Food handler and processor hygiene

Good personal hygiene can prevent food poisoning. The harmful microorganisms that cause food poisoning can be transferred by individuals, including healthy people, through contact with their noses, mouths, hair, clothes, or food. Therefore, food handlers and processors must take hygiene seriously.

Food handlers must always wash their hands after using the toilet, blowing their nose, coughing or sneezing, and handling waste or spoiled food products. In addition, food handlers must always be clean and change their uniforms daily.

General health and reporting of illness: Food handlers must report illnesses such as diarrhea, colds, food poisoning, injuries, or open wounds to their manager. Inspections must be done regularly to ensure grains are properly stored in bunkers.

Adverse weather conditions, such as rainwater pooling or wind stress on tarps, must also be monitored to prevent contamination or infestations. Inspections of tarps, A-frames, iron, erosion, water contamination, and bunker pads should document signs of insect infestations.

Occupational health and hygiene of employees: Protecting employees from health risks is important. Occupational diseases may take years to manifest, so medical reports and continuous monitoring of worker conditions are essential. Exposure to chemicals, fumes, gases, smoke, noise, lighting, heat, and vibrations must be identified, measured, evaluated, and controlled.

Occupational safety legislation: The Occupational Health and Safety Act (No. 85 of 1993, Regulation 24) ensures employee safety by implementing measures to prevent incidents and accidents. Food handlers must be trained to follow safety rules, interpret safety signs, and wear protective clothing. Supervisors must provide guidance to promote safe working procedures and prevent injuries. First aid must be readily available when accidents occur. All incidents and accidents experienced in a food processing facility must be reported as per the Occupational Health and Safety Act [31].

3.6.3 The importance of maintaining good personal hygiene

Maintaining good personal hygiene is crucial for preventing foodborne diseases. Therefore, food handlers must consistently wash their hands and uphold cleanliness standards. Any illnesses or injuries must be reported to supervisors. Regular, thorough inspections are essential to ensure proper storage and prevent insect infestations.

It is imperative to prioritize occupational health and safety measures to protect employees from harmful conditions. Strict adherence to occupational safety legislation is mandatory to prevent accidents. Food handlers must undergo extensive training to strictly adhere to safety rules and employ safe methods to prevent injuries. All incidents and accidents must be reported following the Occupational Health and Safety Act (No. 85 of 1993, Regulation 24).

The distribution of food to retailers and the market involves transferring food products markets, or end consumers. It involves product transportation and storage. After being processed, ready-to-eat (RTE) foods are placed on trucks for delivery to intended destination.

To protect food products during distribution, trucks must maintain appropriate temperature, ensuring the products are fresh and safe to eat. Improper refrigeration temperatures can create favorable conditions for microbial growth [14].

Food products delivered to wholesalers must be stored under proper conditions. High temperatures or excessive moisture in the air can contribute to spoilage and microbial growth. Wholesalers should follow GMPs to keep food products safe. The principles of HACCP can also protect food from biological, physical, and chemical food safety hazards. Proper controls can minimize the risk of contamination and cross-contamination during distribution [32].

3.7 Safeguarding food in retail stores and markets

After food products have been delivered to grocery stores, they must be carefully placed on shelves to prevent spoilage or contamination. RTE foods must be placed on refrigerated shelves and sold before their expiry dates. Fresh, non-packaged produce must be placed in the produce section, where customers can select fruits and vegetables safely.

Key obligations of the food handling business include:

Safety: Businesses handling food are obligated not to sell unsafe food.

Responsibility: Food businesses are responsible for the safety of the food products they transport, store, and sell.

Traceability: All businesses and suppliers that produce and handle food must be identifiable and traceable.

Transparency: All authorities must be informed if the food transported, stored, or sold by the food business is unsafe.

Emergency: All businesses handling food must immediately withdraw unsafe products from the retail or market shelves.

Prevention: Food handling businesses must identify critical points in their processes, apply controls, and review them regularly.

Cooperation: Food handling businesses must cooperate with relevant authorities to reduce food safety risks [33].

3.7.1 Food safety in supermarkets and grocery stores

Supermarkets and grocery stores provide valuable services, ranging from food processing to serving. Therefore, operators need to adhere to comprehensive food safety procedures. The following general guidelines apply to all food-handling businesses and activities to achieve the minimum standards to ensure consumer safety [34]:

Facility environment: Food handling facilities must be located in safe, garbage-free environments with no stagnant water.

Facility layout and design: Food handling facilities must provide adequate receiving and loading platforms protected from rain and vermin. Separate areas for storage, processing, and packaging must be available.

Food handling and storage: Food storage areas must have sufficient drainage, be easy to clean, have temperature control, and be well-ventilated with power backup.

Equipment and containers: Equipment must be designed and mounted so that it is easy to service and clean, including its surrounding areas. Maintenance and cleaning procedures should be documented and records kept.

Employee amenities: The facility must have adequate facilities for personal hygiene, including toilet and hand washing stations with soap and potable hot and cold water, along with changing rooms.

Cleaning and hygiene: Programs that establish cleaning schedules, responsibilities, methods, equipment, and materials suitable for on-premises food handling must be available. Appropriate chemical storage areas should be separated to prevent food contamination.

Water quality: Only potable water should be used for food production, cleaning, and staffing facilities.

Waste management: Safe collection, storage, and disposal procedures should be followed using suitable equipment to safeguard food. Cleanliness in waste storage areas and prevention of cross-contamination between food and non-food products are vital.

Pest control: Trained personnel must be assigned to implement pest control measures to monitor, identify, control, and document pest infestations.

Transport of food products: Food and non-food products must be transported in clean, pest-free containers under suitable temperature and humidity to prevent spoilage and cross-contamination.

Food handler training: All employees must be trained in food safety principles and practices according to their roles.

Food preparation and serving: Establishments such as restaurants, cafeterias, and hospitals play a critical role in the food value chain. Separate workstations must be provided for vegetables, raw meat, dairy confectioneries, and salads. These food items cannot be prepared at the same stations using the same utensils. Staff must wear appropriate protective clothing. Heating and cooling temperatures must be monitored and managed effectively, with control measures implemented to prevent contamination [35].

3.8 Safeguarding food at the household level

The final stage of the food chain occurs at the household level, where food products purchased from retailers, grocery stores, or markets are prepared and consumed. At this stage, it is imperative to prevent contamination of RTE foods and minimize the risk of foodborne illnesses.

Improperly washed cooking utensils and cutting boards are common sources of contamination. In addition, pathogens can transfer from unwashed hands to food. Dishcloths and sponges can harbor pathogens when left moist for extended periods, contaminating utensils and food.

It is also important to keep food products fresh to retain their highest nutrient value. To keep fruits and vegetables fresh, they must be stored at the correct temperatures. RTE foods require different temperature and humidity levels to remain fresh and safe for consumption.

When washing and cleaning vegetables, hard rinds and firm skin may be scrubbed with a vegetable brush. The water used to clean vegetables must not be more than 10 degrees colder than the vegetables to prevent microorganisms from entering the stem or blossom end of the produce.

Detergents or bleach solutions must not be used to wash fruits and vegetables, as most fresh produce is porous and could absorb these chemicals, changing their safety and taste.

Leafy green vegetables must be washed separately by rinsing leaves individually and discarding torn or bruised outer leaves. Leaves must be immersed in cold water for a few minutes to loosen sand and dirt. After washing, the leaves should be dried using a paper towel.

Apples, cucumbers, and other firm-skinned produce must be washed or peeled to remove waxy preservatives.

Root vegetables must be cleaned using a firm scrubbing brush under lukewarm running water.

Melons with netted surfaces may contain anchored microorganisms that can be transferred to the interior surfaces during peeling and cutting. To minimize the risks, these melons must be washed thoroughly under running water before peeling or cutting.

Peaches, plums, and other soft fruits must be washed under running water and dried with a paper towel.

Grapes, cherries, and berries must be stored unwashed until ready to use. Discard moldy or spoiled items before storage. Fruit must be gently washed under cool running water before consuming.

Mushrooms should be cleaned with a soft brush or wiped with a damp paper towel to remove dirt.

Herbs must be rinsed by plunging and rustling in a cool water bowl and drying with a paper towel [15].

4. Conclusions

The HACCP system plays a crucial role in safeguarding food at various stages of the food chain, including the production of meat and poultry, dairy, seafood, and fresh produce. It helps to identify and address potential hazards that may occur during food production on farms and in processing facilities.

HACCP also protects the food served to customers in restaurants, cafes, hospitals, and nursing homes, ensuring its quality and safety. By identifying potential hazards, such as cross-contamination during food preparation, and implementing effective control measures, the risk of foodborne illnesses can be significantly reduced.

Emerging challenges in food safety are of critical concern due to their potential negative impact on public health and economies. The globalization of the food supply chain has introduced novel and re-emerging foodborne pathogens. These challenges are further compounded by climate change, its impacts on food safety, and the increasing use of technology in the food industry. Addressing these issues requires a coordinated and integrated approach that involves all stakeholders, including governments, food producers, the food industry, and consumers.

In addition, it is important to develop and implement robust food safety regulations and guidelines. These must include strategies to safeguard food at all stages of the food chain, from farm to fork. They must also be regularly reviewed and updated to reflect new risks and technologies. Working together, all stakeholders in the food chain can assist in ensuring that the food produced and consumed is safe, healthy, and free from pathogens.

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Conflict of interest

The author declares no conflict of interest in writing this book chapter.

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