Food Reviews International

ISSN: 8755-9129 (Print) 1525-6103 (Online) Journal homepage: www.tandfonline.com/journals/lfri20

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To cite this article: Charles Odilichukwu R. Okpala & Małgorzata Korzeniowska (2023) Understanding the Relevance of Quality Management in Agro-food Product Industry: From Ethical Considerations to Assuring Food Hygiene Quality Safety Standards and Its Associated Processes, Food Reviews International, 39:4, 1879-1952, DOI: 10.1080/87559129.2021.1938600

To link to this article: https://doi.org/10.1080/87559129.2021.1938600

FOOD REVIEWS INTERNATIONAL
2023, VOL. 39, NO. 4, 1879–1952
https://doi.org/10.1080/87559129.2021.1938600

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REVIEW

Understanding the Relevance of Quality Management in Agro-food Product Industry: From Ethical Considerations to Assuring Food Hygiene Quality Safety Standards and Its Associated Processes

Charles Odilichukwu R. Okpala and Małgorzata Korzeniowska

Department of Functional Food Products Development, Faculty of Biotechnology and Food Sciences, Wrocław University of Environmental and Life Sciences, Wrocław, Poland

ABSTRACT

The continuous improvement in good practices and implementation of hazard analysis and critical control points (HACCP) remains very crucial for food hygiene quality safety to steadily thrive in the agro-food product industry sector. To improve the agro-food product quality, the dependency of quality management (QM) on such key facets as quality assurance (QA), control, improvement, and planning appears to be on the rise. Herein, how food hygiene quality safety standards and their associated processes have been assured is described. To understand the relevance of QM in the (above-mentioned) processes, we discuss some ethical quality considerations, food quality safety standards, HACCP fundamentals/implementation, QA control systems, other quality standards associated with agro-food industry, together with supplementary essentials associated with quality. Through the combined efforts of HACCP and QA control points (QACP) such as improved food hygiene, both quality, and safety levels can be further enhanced and sustained. Establishing the QM system within a given agro-food product enterprise is not the real deal, what matters most is how to maintain and sustain it. Some challenges encountered during the auditing/implementation processes of food safety management systems, as well as directions for future studies, involving QM, QA, and food hygiene quality safety, are presented.

KEYWORDS

Agrofood industry; quality management; food safety; food quality; product quality; quality improvement

Introduction

Quality management (QM): Some basic links to agro-food product industry

Quality management (QM), strategically integrated into operations of many companies, has been largely based on mutual yet reinforcing principles, which are supported by a set of practices.[1,2] Key in determining the quality objectives, policy, and responsibilities at a wide range of sectors, QM remains implemented through quality assurance (QA), control, improvement and planning, providing unlimited emphasis to practice, especially if the primary objective of the organisation (or product quality) achievement were to be consistent.[3,4] For the QM to be effective, therefore, it has to utilise components like continuous improvement/learning, customer focus and orientation, empowerment and teamwork, human resource focus, quality tools, robust management structure, strategic planning/leadership and supplier support.[5–7] Each QM expert has to possess the prerequisite 'key practices', which remain fundamental not only for the attainment of the superior quality outcomes,[8] but also for the realisation of the (robust) organisational improvements.[1] In addition, the quality definitions

CONTACT Charles Odilichukwu R. Okpala charlesokpala@gmail.com

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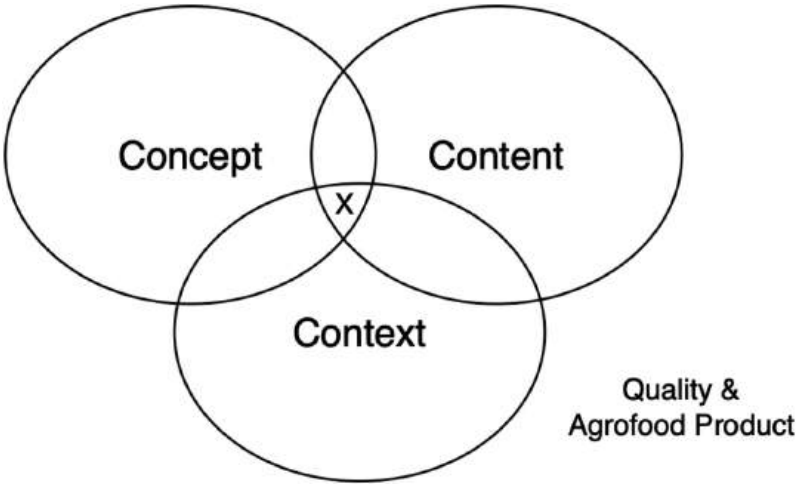

Figure 1. A diagrammatic representation of the interaction space between concept, content and context perspectives of quality of a given agro-food product. The interaction between the three, indicated with "X", that is, concept versus content versus context perspectives of quality (Source: Okpala & Korzeniowska [15]).

facilitate both the implementation processes and the working of performance-based parameters, which arise from the quantification of delivery of values to the consumers/stakeholders. [9] Previous studies about QM practice have involved employees' empowerment/relationship, employees' training/learning, [10–13] supplier closeness and relationship, [10,12–14] as well as QM's link to the customers' closeness/focus.[10,12,14]

Quality should neither be perceived as a scientific or technical word, nor as physical entity with a fixed position in space and time. It should be considered an essential aspect of any existing economic activity, with direct impact on consumer, producer, as well as product and service.[15] Indeed, quality attributes in agro-food products remain somewhat difficult to identify and observe. Quality attributes specific to one product stands it unique compared to the other, which underscores that there are concept, content, and context perspectives of quality.[15] A diagrammatic representation of the interaction space between concept, content and context perspectives of quality of a given agro-food product is shown in Fig. 1. We understood that there is likely to be a thin line that would separate concept, content and context perspectives of quality, especially when it involves the choice/decision-making of purchase of agro-food products. On the other hand, and also specific to the agro-food product industry, quality would involve a wide range of ideas, from the aesthetic standard for product set by experienced users, the extent to which a product fulfils the consumer needs/wants, conformance to requirements, degree of excellence (of a food product), and summation of attributes that govern food product acceptability to buyer/consumer.[16] The quality systems can also comprise management structures, infrastructures, product characteristics followed by the production processes.[17] Therefore, making QM complete demands quality practice geared towards attaining world-class quality.[18] The prospect of individuals to compete via QM initiatives is also relevant to agro-food product industry. Some firms sometimes do not actualise this, making such unable to compete effectively within the (national/global) market.[7]

Some highlights about food safety in the agro-food product supply chain

From the preservation, processing, production, and storage standpoints, to sustain global food systems would involve such elements as climate, available land space, and technology. Despite the focus to have effective quality control at all the stages of the food supply chain,[19] there are some notable challenges that confront the food sector can include a) highly perishable food products; b) manual/very limited

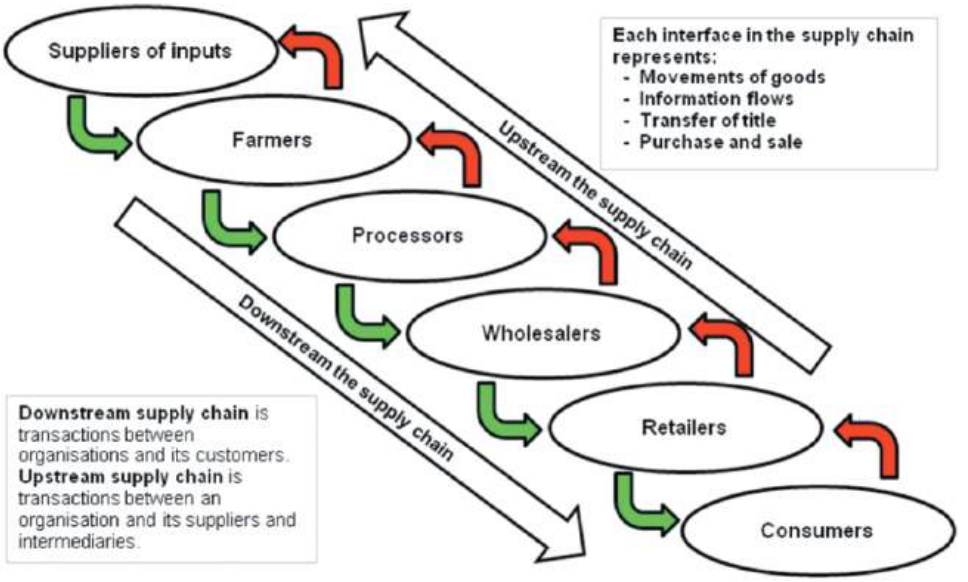

Figure 2. A diagrammatic representation of a typical agro-food product supply chain. From the consumers to the suppliers, the downstream (green) and upstream (red) direction flow of transactions takes place within the supply chain (Source: Costa-Font & Revoredo-Giha.[21])

automatic operation(s); c) variations in the quality of raw materials; d) augmented dissimilarities of composition/products; e) processing techniques; and f) reduced volume of batches.[20] A diagrammatic representation of a typical agro-food product supply chain can be seen in Fig. 2. The direction of downstream and upstream aspects of the food supply chain can be seen to interconnect with the interface transaction(s), which is represented by the flow of information, movement of goods, purchase, and sale as well as the transfer of title(s).[21] As the food industry continually searches for more innovative production strategies, there is a need for efforts to persist in the areas of consumer protection and food preservation.[22] Despite being responsible for delivering an objective as well as a transparent food safety plan, the agro-food product industry must ensure that the hazard measures are in place for (product) safety.[23] The affordability of applying/introducing food safety instrument determines the degree of progress of the local (food) management strategies.[23] Notable factors that influence food quality/safety can include a) inadequate storage; b) inappropriate temperature levels; c) poor air quality; d) poor humidity; and e) poor lighting. In addition, farmers, suppliers, wholesalers, retailers as well as transporters are obliged to sustain the conditions of food products' quality and safety.[24]

Globally, many countries are prioritising to improve food control systems by the way of food laws as well as food hygiene regulations/standards. However, food quality/safety is still confronted with challenges, and some examples can include a) importation and exportation of food; b) street foods; c) food transportation; d) zoonotic pathogens; and e) chemical agents in foods.[25] From the global viewpoint, it can be said that the consumers' persistence for food safety has contributed in facilitating the food industries to vigorously pursue the implementation of various (food safety) standards, like British Retail Consortium (BRC), International Featured Standards (IFS), Hazard Analysis of Critical Control Points (HACCP) as well as ISO 22000:2005. Yet, not all the formal quality systems are welcomed by food industries.[26] Two major international organisations involved in the development of food quality safety systems include a) Food and Agricultural Organization (FAO); and b) World Health Organization (WHO), both largely collaborating through the Codex Alimentarius Commission, implementing the joint FAO/WHO Food Standards Programme. Of lesser extent, however, the International Commission on Microbiological Specification for Foods (ICMSF),

United Nations Industrial Development Organization (UNIDO), General Agreement on Tariffs and Trade (GATT), International Standard Organization (ISO), International Organization of Consumer Union (IOCU) and International Dairy Federation (IDF) have been understood to participate in the international food quality safety control.[27]

As good practices contribute to protect the production process within the agro-food industry/sector, the QA plays a vital role to make the operational activities work effectively and efficiently. Depending on the purpose, the focus of good practices can be of private or public aspects, despite the complexities associated with the food supply chain.[28] Hazard analysis and critical control point (HACCP), already acknowledged by the FAO+WHO, European Commission (EC) as well as Australian and New Zealand Food Authority, is increasingly becoming popular in the developing countries, as a means of assuring the food quality safety.[29] In addition, HACCP is also very relevant to religious food safety.[30] In the situation of export and across trade barrier(s), food safety standards have challenges, like a) delicate nature of fresh food product regional trade; b) role of farm-to-table approaches that assure safety; c) the role of the public sector between nations to facilitate trade; and d) potential role of nations based on the agreement to resolve disputes and determine equivalencies of standards.[23] In the European market also, food quality standards remain critical in meeting consumers'/regulatory bodies' requirements.[31]

Justification and specific objective of review

Shelf life concerns are among key issues that continually pose a wide range of challenges to the food product supply chain, from product development, processing, to the distribution as well as storage stages [32]. Further, the food product quality safety would continue to require (product) stability in order to fulfill basic and fundamental consumer expectations.[33] Previous published synthesised literature reviews, from good practices, quality assurance/management systems, to related aspects relevant to the agro-food product industry conducted in the course of the past two decades by several researchers, is summarised in Table 1. Largely, the current state-of-the-art has focused on areas like auditing, food safety, food quality standards in the food industry,[26] good practices for fresh (agro-food) produce/total chain safety,[34,42] food safety management system,[37,39] HACCP certification with the quality standard,[49,51] as well as understanding the food quality, entities, and systems.[46] Applicable to the agro-food product industry, there are areas like quality assurance,[38,44,45,47] quality function deployment,[50] quality management[20,36] and quality safety standards/systems[40,43] that have been previously reported. Reviews concerning food quality that are connected to waste[35] and organisational issues in providing safe wholesome food[48] can also be seen in Table 1.

Despite the above-mentioned previously conducted reviews, the current status of QM in connection with food hygiene quality safety standards within the agro-food product industry, in our opinion, appears not fully established. According to Okpala et al. [52] the continuous assembly/synthesis of relevant reviews together with contextualisation and quantification of published data is necessary if the existing information is to be supplemented. Thus, understanding the current status of QM, particularly on how it drives the progress of good practices within the agro-food product industry should be a useful start. Besides, the food industry continually seeks to increase the food product quality and consumer protection/safety through the practice of quality assurance, good (hygiene food safety quality) practices/processes, legislative and regulatory standards, and other quality-related processes. In this current review, how food hygiene quality safety standards and its associated processes have been assured is described. In order to understand the relevance of QM in the (above-mentioned) processes, some ethical quality considerations, food quality safety standards, HACCP fundamentals/implementation, QA control systems, other quality standards associated with the agro-food industry together with supplementary essentials associated with quality will be discussed. In addition, some challenges encountered during the auditing/ implementation processes of food safety management systems, as well as directions for future studies, involving QM, QA, and food hygiene quality safety, will be presented.

Table 1: Summary of previous published synthesized literature, from good practices, quality assurance/management systems, to related aspects relevant to agro-food product industry

References	Objective/purpose of review	Major sections covered
Kotsanopoulos and Arvanitoyannis [26]	Examined the role of audits and food safety and quality assessment systems in the food industry, with brief description about global food safety and quality standards	-History of Auditing; -The Auditing Process; -The Role of Safety and Quality Control Systems; -The Role of Governments; -Food Safety and Quality Standards; -Auditing Authorities in Europe, U.S., Autralia and New Zealand; -Implementation of Food Safety Standards in Asia and Food Safety Authorities
Wongsprawmas, Canavari, and Waisarayutt [34]	To describe and analyze current situation of good agricultural practices (GAP) standards implemented in fresh (agro-food) produce production in Thailand	- Law and regulations regarding to food safety in Thai food production industry; - GAP scheme adoption in Thai fresh produce production; -Comparisons of GAP standards; and - Challenges in adopting food safety assurance system in Thai fresh produce production.
Śmiechowska and Kłobukowski [35]	To evaluate current knowledge of issue of food quality in connection with waste, its importance for natural environment, state budget and home dwellings	-The notion of quality; -The cause of food waste; and -Ways to counteract food waste.
Kibe and Wanjau [36]	Explores quality management systems and their influence on performance of food processing firms in Kenya	-Food safety assurance systems; -Hazard analysis critical control points (HACCP); -Seven principles of HACCP; -HACCP plan; -Organizational Procedure; -Conceptual framework; and -Critical review
Dora, Kumar, Goubergen, et al. [20]	To review assessment strategies of food quality management system using a feasibility study for EU small-medium sized (food) enterprises	-Introduction of literature of quality and quality management implementation; -Summary of methodology employed to conduct the review; -Results of feasibility study was presented; -Benefits of and barriers to food industry; and -Limitations of study presented, followed by conclusions and future research.
Jacxsens, Luning, Marcelis, van Boekel et al. [37]	To review principles and usefulness of various tools developed in EU to support food business operators in enhancing their food safety management systems (FSMS)	-Process of performance assessment, selection and improvement of food safety management systems; -Diagnostic tools; -Selection tools; -Improvement tools; and -FMSM support systems
Karipidis, Athanassiadis, Aggelopoulos, and Giompliakis [38]	To pinpoint factors that affect decision of small enterprises to adopt quality assurance system (QAS) with the intent of facilitating its rapid diffusion in European small food enterprises	-Benefits/advantages implementation of QAS; -Barriers to implementation of QAS; and -QAS diffusion policy
Luning, Marcelis, Rovira, van der Spiegel, Uyttendaele, et al.. [39]	To discuss core assurance activities, its contributions to assurance and how to judge activities in a company's food safety management system (FSMS)	-Food safety management system; -Structure diagnostic instrument; -Core assurance activities; -Assessment of assurance activities; and -Usefulness of diagnostic instrument and future perspectives
Trienekens and Zuurbier [40]	To review quality and safety standards in the food industry, developments and challenges	-Need for food safety standards; -Quality and safety characteristics of food production; -Food quality standards; -Implementation and impact
Raspor and Jevšnik [41]	Analyses good practices at different levels of food production, distribution and consumption	-Good practices from producers to consumers; -Food safety parameters; -Food safety dilemma of consumer; -Good nutritional practice from producer to consumers

(*Continued*)

Table 1 (Continued).

References	Objective/purpose of review	Major sections covered
Raspor [42]	To demonstrate how good practices can contribute to the attainment of total food chain safety	-Background and how to reach acceptable food safety; -Consumer-neglected link in the food chain; -New food safety concept; and -Future outlooks
Knaflewska and Pospiech [43]	To outline appropriate standards and systems functioning in food industry as well as legal basis for their application	-Safefood and legal basis; -Traceability in practice; Systems of food quality
Da Cruz, Cenci and Maia [44]	To present information about main factors responsible for the elaboration of quality assurance system for produce plants of food industry	-Quality assurance; -Good agricultural practices (GAP); -Good manufacturing practices (GMP); -Sanitation standard operating procedures (SSOP); -Hazard analysis critical control points (HACCP);and -Future prospects
Manning, Baines, and Chadd.[45]	To critically analyze how effectively quality assurance (QA) standards has been implemented in the integrated UK food supply chain	-QA schemes; -Organizational/supply chain QA models; -Current QA models; and -Benchmarking within food supply chains
Doyon and Lagimonière [46]	To focus a better understanding and defining food quality, entities and system component	-Briefs about quality assurance, GMP, HACCP, Food safety, audit, risks and certification; -Risk analysis tools for quality management are traceability system; and -Traceability tools and definition, concept, principles and guidelines/standards
Sikora and Strada [47]	An overview of safety and quality assurance and management systems in food industry	-Food quality and safety; -Quality assurance and management systems; and - Making quality management systems work
Manning and Baines [48]	To identify organizational issues if management systems primarily focused on minimizing quality cost rather than providing safe wholesome food	-Private assurance schemes; - Why quality assurance; -Criteria for certification bodies; -Regulatory inspection vs quality assurance schemes; -Whole supply chain assurance; - Hazard analysis critical control points (HACCP); and -Risk management and impact of food globalization
Jatib [49]	To comparatively analyze HACCP, Quality and Origin Protocol, and ISO9001 Quality Management affecting agribusinesses in Argentina	-Food safety self control program; -Green Beef Protocol – Self Certification Model; and - Implementation of Strategic Plan and ISO9001
Costa, Dekker and Jongen [50]	To review the application of quality function deployment (QFD) in the food industry	- QFD implementation; -QFD in food industry; - Benefits and drawbacks of QFD for food research and development (R&D); -Challenges remaining for QFD practitioners in food R&D.
Caswell, Bredahl and Hooker [3]	How adoption of new quality management metasystems affects specifics of food systems and how these effects might be quantified	-Why adopt 'metasystem'?; -Internal benefits and costs of metasystems; -Transaction costs and system efficiencies; -Developing a competitive advantage; -Interactions among metasystems; -HACCP as a mandatory quality control metasystems; -ISO9000 series as a voluntary quality control metasystem; -Quasi-voluntary metasystem: How free a choice? and -How can the effects of metasystem be evaluated?
Barendsz [51]	To review developments in HACCP certification, the standardisation of risk assessment, the necessity of chain formation in the agro-food sector and the improvement of global communication	-HACCP as part of total quality management system; -HACCP certification; -Risk assessment; -agro-food chains; and -Global communication

Some ethical quality considerations applicable to agro-food product industry

It is believed that QM emerged because factory management over time was found in desperate need for quality manager functions, which would strategically balance the authority of the production managers. Indeed, this approach has helped to address several quality concerns, which at the end was found to strengthen the control systems within acceptable (quality-driven) standards.[53] Markkula Center of Applied Ethics at Santa Clara University considered ethics as well-founded standards of right and wrong, which prescribes what humans ought to do, based on benefits to society, fairness, obligations, rights, or specific virtues.[54] So, ethics would well apply to QM as it does to all aspects of human endeavours. Wicks[55] indicated that to implement QM requires the understanding of what makes it to work, and what circumstances provides it a sustainable advantage. Thus, there are moral values (also called 'value dynamics') that have to be developed if QM is to work.[4] In addition, Ahmed and Machold [56] understood that both ethics and morality could increase awareness about quality practice. In fact, both ethics and morality, if and when rigorously incorporated into an organization could play a strong role to improve the managerial (and operational) aspects of the QM experience. In addition, quality has a paradigm viewpoint that explicitly incorporates virtue, which cannot be successfully managed without moral values. Ethical behaviour would therefore assume complete control of quality to answer moral questions adequately,[57] which can apply to quality assurance/management of the agro-food product industry.

Especially in the real-time scenario, the collective package of integrity-trust-virtue continually fails to stand significant and strong, especially in its meaning, regardless of the QM components. Therefore, if the ethical issues were to be considered particularly within the quality framework, the latter should be based on the belief in the goodness of people, as well as continuous quality improvement. Besides, the usefulness of ethics in QM should be made to involve an evidenced commitment to the ethical standards, together with virtue and integrity – an attitudinal and value-based method of achieving an increased level of quality practice.[56] Additionally, in order to realise ethical accountability, there are a number of useful elements that must be put in place, and some examples include benefits, care, equity, integrity, liberty, no-harm, transparency, and voice.[56] In addition, Barney and Hansen [58] understood that trustworthiness could serve as a key source of competitive advantage. Actually, there are three types of trust that have been established in the relevant literature, which include: weak, semi-strong, and strong. Further, Wicks [55] understood that cooperation and trust together could empower the management of a given organization so as to increase their productivity, which would result in the continuous (operational) improvement, customer satisfaction as well as short/long-term kind of advances/successes, particularly in the delivery of QM practice. Thus, the combined working of respect and trust in managing quality processes is very crucial and essential. Besides, that is why good positive supervision certainly motivates employees. Treating employees respectfully when there are undertaking meaningful duties in their workplace(s) promotes freedom as well as liberty, and should not be misused.[57,59,60] Behaviour, communication, considerations, and values of individuals are well known to strengthen the foundation for relational responsibility. Continually, effective and responsible control should persistently underpin the internal process, particularly when combined with personal care. Then, customers, employees, and society can strive for QM practice.[57–60] Indeed, all the above-mentioned ethical quality considerations apply well to the agro-food product establishment/industry.

Food safety knowledge – Some key fundamentals

Regardless of the location, to prepare food in the right hygienic standards, there has to be the appropriate knowledge that produces the effective food-handling skills. To achieve this, there has to be the right motivation to act on that knowledge. For emphasis, knowledge entails when factual information employed by a learner is utilised to perform a given task in the desired and specific manner.[61] However, to achieve the required level of food safety knowledge, there must be the education that is fortified with proven validity or reliability instruments.[62] Previous research has

Figure 3. Key direct and indirect components that influence food safety knowledge.

revealed that people have the capacity to increase their food safety knowledge with time and practice.[63] In particular, it is believed that females would have higher food safety knowledge scores compared with the males. In addition, the younger people are believed to demonstrate the greater need to undertake additional food safety education.[63–66] There is also the understanding that people from the urban are likely to have lower food safety knowledge scores compared with those from rural areas.[63,64]

Food safety knowledge comprises various components, which could deliver either direct or indirect influence, as depicted in Fig. 3. It will be remiss to discuss food safety knowledge without directly involving food handling, food safety systems, good practices, HACCP, food quality/standards, and indirectly involving food culture/traditions, and production/processing. Various studies that investigated food safety knowledge has involved one or more of the above mentioned. Indeed, accepting food safety systems has put employees' training under the critical observations.[67,68] In order to put food safety knowledge into action at any given food enterprise, the performance of the working procedures must operate at a high-quality level, which must adhere to the food hygiene with HACCP, and its associated principles. This has to be so, in order to assure efficiency in food safety, to prevent foodborne diseases,[68] which is also depicted in Fig. 3. If food safety knowledge is absent, or not deficient among food service workers, there is likelihood that the spread of foodborne outbreaks to become a reality.[69] Besides, there are common food handling errors that can occur, for example, allowing too much of a time lapse when cooling food, cooling food inappropriately, inadequate cooking, reheating of foods consumption of food obtained from unsafe sources.[62,70]

Despite the adherence to existing framework/standards, to implement/practice food safety knowledge remains very relative as it would differ from person to person, place to place, as well as scenario to scenario. Regards person-to-person, the food safety knowledge of food service personnel in a typical restaurant with diverse menus, would differ from food service personnel in, for instance, a given fish or meat shop. If food safety knowledge of consumers for example, specific to the status of kitchen components, were to be assessed, the outcomes would not be the same as food safety knowledge of food service providers in a restaurant. Moreover, there are numerous studies already conducted on food safety knowledge (and practices), and examples range from elderly people living at home,[71] consumers,[72,73] street food vendors in a given city,[74] food handlers,[68,75] to catering employees like head chefs, managers, [76,77] as well as students in tertiary institutions.[78–80]

Food quality safety standards – a primer

Food safety standard captures a wide range of items, from hygiene standards of food packaging materials, labelling standards of food labels, agricultural production environment, to harmful micro-organisms and pollutants in foods.[81] Food quality/safety standard has always been underpinned by the work of the Codex Alimentarius Commission (CAC), which has been positioned as the global policy reference point for the food producers, processors, consumers, as well as the national food safety agencies. Both FAO and WHO jointly run the CAC, which protects the global public health, and makes an effort to balance the food trade relationships.[40,82] Since its commencement in 1963, the CAC is well-known to have produced several food safety standards, guidelines, and codes of practices. As of 2004, the CAC was made up of 188 member countries, one member organization (The EU), 229 observers, and 16 UN agencies.[82] The CAC produced the Codex Alimentarius, which has harmonised international food standards, guidelines, and codes of practice. Further, the Codex Alimentarius has basic rules that food hygiene safety applies within the entire food (supply) chain, from the (original) production to the (final) consumer.[33] The standards of Codex Alimentarius serve as a benchmark to the various national food measures as well as regulations within the legal parameters of the Uruguay Round Agreement.[40] The CAC equally provides the platform for developing countries to join the international community in developing their food quality safety guidelines, standards, and recommendations. Whilst countries are permitted to set their own standards, as sustained by a well-thought-through risk assessment framework/strategy, the CAC continually sets the basis for the equivalency judgment, between the (food quality safety) control systems, which can be considered as under implementation by the various countries.[83]

Importantly, food safety standards are legislatively relevant to the implementation and improvement of QM in the agro-food product industry.[17] In addition, food safety issues across countries equally vary and account for differences in legislation/private sector responses.[84] Enforcing food quality safety standards through legislation also helps establishments/units develop private standards that tackle the complex food supply chain safety issues.[85] Specifically, the private food quality safety standards aim to: a) eliminate multiple audits of food suppliers-manufacturers via having their processes certified; b) improve supplier consistency and standards, so as to avoid failure; c) provide concise information about production processes in case of food incidents; and d) support consumer and retail objectives by transferring their demands to parties upstream the chain.[86] At the international levels, the food quality safety standard helps the food product processors to operate with the commercial as well as contractual arrangements, and to minimise the frequency of disruptive food safety incidents.[51] However, there are still some pressing challenges encountered by smallholder agriculture, specifically concerning the overall growing complexities of private food (quality and) safety standards. The challenges encountered by smallholder agriculture have specifically been found in developing countries.[87] Through food quality safety standards, the small-scale producers are able to effectively integrate into the supermarket supply chains.[88] In addition, it is important to reiterate that food-borne diseases that confront food quality safety pose great challenge to the public health authorities, food industries, and consumers.[89] Thus, food quality safety standards are very important/vital to the global food supply chain. As the efforts continue to ensure food quality safety rise to the global challenges, it is imperative that the policymakers equally persist on the various food industries to comply with the food (quality safety) standards. This is because the final market of the product depends on the several stages of (agro-food) supply chain.[85]

The retail sector within the various chains of agro-food industries are considered useful in elevating food quality safety standards to higher levels. In fact, two voluntary consensus standards, namely Global GAP and British Retail Consortium (BRC) are technical standards of retailers together with their interest groups, which differ from the HACCP or ISO-based standards that have evolved through either the public authorities or inter-government agencies.[90] As the supermarket chains implement their own food safety standards,[91] every agro-food industry/unit has to take full responsibility for its own food quality safety unit. This idea has always been carried out to assure the credibility as well as

the effectiveness of the existent food quality safety regulatory framework.[84] In addition, there are the halal and kosher, both have acquired their own quality certification and standards, and are continually and increasingly elevating their quality framework.[92] Practically, food processors should be the ones who determine if the final products meet the prerequisite criteria as prescribed in the stated food quality safety standards. For instance, the sampling plans within the given food industry would have to relay the reports with the decision of whether to either accept or reject the batch of food products. Different regulatory bodies set the criteria for food quality safety and guide how preventive actions within the manufacturing process are defined.[37] The food quality safety standards' focus on characteristic properties of food products should include producer practices within the food supply chain, as well as its traceability. Therefore, to operate within the minimum quality standards (MQS) should be the focus, because of the influence such would deliver to the food market/trade as well as policy-makers. The primary aim of operating within the MQS should therefore be to assure that food sold to consumers fulfils the desired food quality safety requirements.[85] Thus, any food-based QM system should include quality safety standards, which has been well established to serve a wide range of (agro) food products.[91]

Good (food hygiene quality safety) practices relevant to agro-food product industry: Some detailed discussions

Good practices cut across all key aspects of the supply chain processes found within the (agro)food industry.[93] When the job roles of all who deliver quality within the food industry/sector are not clearly defined as well as understood, the integrity of food safety can be compromised. Thus, there is a need to reiterate the importance of good practices in the domain of food quality and consumer protection.[41] Good practices – described in the Codes of Practice, are designed by government bodies representing consumers (e.g., UK Food Standards Agency), producers' organizations (e.g., Europe/AfricanCaribbeanePacific Liason Committee – COLEACP), including importers/retailers' consortia (e.g., British Retail Consortium – BRC, Food Policy Council – FPC, Commission for Instruments and Methods of Observation – CIMO, together with the Euro-Retailer Produce Working Group – EUREP).[28] Within the food systems, these (Codes of Practice) involve the various quality assurance activities, which are consistent with the control of food production (as well as food-related processes).[28]

Summary of previous studies that investigated good (food hygiene quality safety) practices across various agro-food product supply chain and related sectors and respective specific study objectives are presented in Table 2. Good manufacturing practice (GMP), good agricultural practice (GAP), good catering practice (GCP), good hygiene practice (GHP), good laboratory practice (GLP), good retail practice (GRP), good storage practice (GSP), and good transport practice (GTP), comprise the key good practices very relevant to the agro-food product industry. Understanding these good practices remains certainly vital in improving the quality and safety of the agro-food supply chain, especially from the producer and consumer perspectives. Detailed discussion on each (above-mentioned) is hereby presented below.

Good manufacturing practice (GMP)

GMP began with the integrity control of individual activities within the production chains with subsequent positive experiences that have been developed over the years. From its first principles/rules in 1968, the WHO of the UN set the GMP standard procedures that dealt with building equipment, documentation, production, and quality control.[42] As the backbone aspects of food processing operations, the GMP aims for consistency in (food) quality/safety, by providing the basic good practice requirements for environment, facility, and workers.[149] GMP involves practical procedures/processes that would help to optimize the quality system, manufacture, and control of products.[42] Similarly, the GMP guidelines specify the activities as well as conditions food

Table 2: Summary of previous studies that investigated good (food hygiene quality safety) practices, showing various agro-food product supply chain and related sectors, together with respective specific study objectives

References	Good (food hygiene quality safety) practices	agro-food product supply chain and related sector	Specific objective of study
Bernhardt and Raschke [94]	GMP	Cane sugar factories/plants in South Africa	To communicate how GMP can be introduced to a sugar factory
Moberg.[32]	GMP	Refrigerated foods	To identify GMP areas that need consideration in developing, processing and marketing refrigerated foods
Rodmanee and Huang [95]	GMP	Herbal product processing in women's community enterprise at a Thailand province	To assess the current hygiene and manufacturing practice in the community herbal processing enterprise/sector prior to GMP implementation
Arkeman, Herlinawati, Wibawa, and Adinegoro [96]	GMP	Bakery small-medium enterprises in Bogor, Indonesia	To formulate strategy for improving food safety based implementation of GMP within bakery small-medium enterprise
Amoa-Awua et al. [97]	GMP (with HACCP)	Traditional kenkey production in Ghana	To manage the hazards, aflatoxins and enteric pathogens associated with the production of an indigenous African fermented maize
Santana et al. [98]	GMP	Public school catering in Salvador, Brazil	To evaluate the food safety of the services used in free schools and adopt GMP in assuring safe food supply
Cusato, Gameiro, Coarassin, Sant'Ana et al. [99]	GMP (with SSOP and HACCP)	Dairy processing plant located in São Paulo, Brazil	To describe the implementation of food safety system and its challenges within a dairy processing plant
Demirbaş and Karagözlü [100]	GMP (with GHP, HACCP and ISO)	Various dairy plants in Turkey	To survey the level of compliance with the food safety changes/improvements mandated by food legislation in Turkey
Konecka-Matyjek, Turlejska, Pelzner, and Szponar [101]	GMP (with GHP and HACCP)	Food production plants within some provinces in Poland	To determine current situation in implementing GMP (with GHP and HACCP) in food production and processing plants
Martinez-Tomé, Vera and Antonia Murca [102]	GMP (with HACCP)	Salads, which are food considered to be high risk in school kitchens	To establish regulated control GMP (with HACCP) system via checklist on salad production in school kitchens so as to improve food safety
De Lima, Medeiros, Dardin and Stangarlin-Fiori [103]	GHP	Food truck used for food distribution	To evaluate the implementation of GHP in food trucks with and without intervention of a food safety expert
Baluka, Miller, and Kaneene [104]	GHP	Food service facilities in a university	To examine individual worker and institutional hygiene practices and bacterial contamination in food service facilities at Makerere University, Uganda
Jianu and Goleţ [105]	GHP	Meat handlers in meat processing units in western Romania	To determine the knowledge of food safety and hygiene and personal hygiene practices among meat handlers and meat processing units in western Romania
Rahman, Arif, Bakar and Talib [106]	GHP	Food vendors in Northern Kuching City, Sarawak	To assess the level of attitude, knowledge and practice and to determine the factors affecting food safety among food vendors in Northern Kuching City, Sarawak
Wambui, Karuri, Lamuka, and Matofari [107]	GHP	Meat handlers in small and medium enterprise (SME) slaughterhouses in Kenya	To determine the GHPs (which include hand-washing, protective clothing, prohibited practices, medical examination and equipment handling) among meat handlers in small and medium enterprise (SME) slaughterhouses
Saad, See and Adil [108]	GHP	Food handlers in the Northern Region of Malaysia	To assess the level of food hygiene practices among food handlers in the Northern Region of Malaysia
Upadhayaya and Ghimire [109]	GHP	Retail meat shops and meat production in Nepal	To assess GHPs in retail meat shops for safe and wholesome meat production as well as understand different roles performed by delegated institutions that ensure quality meat production in Nepal

(*Continued*)

Table 2 (Continued).

References	Good (food hygiene quality safety) practices	agro-food product supply chain and related sector	Specific objective of study
Ifeadike, Ironkwe, Adogu, Nnebue [110]	GHP	Food handlers and establishments in the Federal Capital Territory, Nigeria	To assess food hygiene practices of food handlers, so as to recommend improved food safety, measures and sanitary conditions within food establishments in Federal Capital Territory, Nigeria
Djekic, Smigic, Kalogianni, Rocha, et al. [111]	GHP (with HACCP)	Different food establishments at three European cities – Belgrade, Thessaloniki and Porto	To determine food hygiene level of different food establishments, examine managers' opinion, and justify food hygiene importance via consumers' perception of food safety/hygiene practices at three European cities
Okpala, Nwobi, and Korzeniowska [112]	GHP (with GSP)	Meat industry in Nsukka, Enugu State of Nigeria	To assess butchers' knowledge and perception of good hygiene and storage practices through a cattle slaughterhouse case analysis.
Cortese, Veiros, Feldman and Cavalli [113]	GHP (with HACCP)	Street food sold at urban center in Brazil's major capital	To assess the street foods' compliance (sold in urban center in major capital of Brazil) with international standards for food safety and to provide data to elaborate specific legislation to ensure safety of street food
Ababio and Adi [114]	GHP (with HACCP)	Food handlers in the Kumasi metropolis, Ghana	To investigate the level of hygiene awareness and practices among food handlers in five major communities of Kumasi metropolis, Ghana
Kunadu, Ofosu, Aboagye and Tano-Debrah [115]	GHP (with GCP)	Food handlers in (institutional) foodservice establishment in Accra, Ghana	To evaluate food safety, attitude, knowledge and practice of food handlers from institutional food service establishments (hospitals, boarding of senior high schools, and prisons) in Accra, Ghana
Sinkel, Khouryieh, Daday, Stone, et al. [116]	GAP	Fresh produce farm at Commonwealth of Kentucky, USA	To assess the knowledge of food safety and attitude towards GAP among fresh produce growers at Kentucky, USA
Da Cruz, Cenci and Maia [117]	GAP	Brazilian produce plant	To evaluate the GAP of a Brazilian produce plant based on checklist (from sanitary equipment, handling of agrochemicals, to hygiene levels)
Nurul Islam, Arshad, Radam and Alias [118]	GAP	Tomato production and marketing in Malaysia	To investigate the effectiveness of GAP in the production and marketing of tomatoes in the Cameron Highlands – an important vegetable growing area in Malaysia
Wongsprawmas, Canavari and Waisarayutt [119]	GAP	Fresh and vegetable industries in Thailand	To explore factors hindering the adoption of GAP in Thai fresh and vegetable industry from the perspective of key stakeholders in different tiers of supply chain
Kokkinakis, Boskou, Fragkiadakis, Kokkinaki, et al. [120]	GAP	Greenhouse growing vegetables at some production sites in Greece	To determine efficiency of GAP protocol (AGRO 2–1 & 2–2) in advancing microbiological quality of peppers and tomatoes grown in greenhouses at some production sites in Greece
Marine, Martin, Adalja, Mathew, et al. [121]	GAP	Vegetable production in Delaware and Maryland, USA	To assess vegetable producers' understanding and implementation of GAP (pre-harvest production practices) via commercial growers meetings in 2010 and 2013
Hamilton, Umber, Hultberg, Tong, et al. [122]	GAP	Minnesota vegetable farm producers	To understand barriers to GAP incorporation by Minnesota vegetable farmers of fruits and vegetables and determine extent actual matched perceived practices
Ganpat, Badrie, Walter, Roberts, et al. [123]	GAP	Small vegetable farmers across Trinidad, West Indies	To assess the extent of compliance with GAPs from the recommended protocols governing product/post-production (practices) among small holder vegetable farmers across Trinidad, West Indies
Rebouças, Santiago, Martins, Menezes, et al. [124]	GCP (with HACCP aspects)	Food handlers and managers of restaurants	To assess the knowledge level, attitudes and practices of food handlers, and knowledge and practices of head chefs and managers in hotels' restaurants of Salvador, Brazil

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Table 2 (Continued).

References	Good (food hygiene quality safety) practices	agro-food product supply chain and related sector	Specific objective of study
Pichler, Ziegler, Aldrian and Allerberger [125]	GCP (with GHP and HACCP)	Food handlers in catering and restaurants and catering companies in Austria	To detect the most important gaps in knowledge on food safety among food handlers, and to identify possible differences in knowledge levels between food handlers from restaurants and catering companies in Vienna, Austria
Nee and Sani [126]	GCP (with GHP and HACCP)	Food handlers at residential colleges and canteens at campus of Universiti Kabangsaan, Malaysia	To evaluate level of knowledge, attitude and practices regarding aspects of food hygiene and safety among food handlers at residential colleges/canteens at a university campus
Veiros, Proença, Santos, Kent-Smith and Rocha [127]	GCP (with HACCP)	University foodservice canteen	To verify procedures and practices related to HACCP prerequisites at university foodservice canteen (using a checklist based on Portuguese and European legislation)
Garayoa, Vitas, Díez-Leturia and Garcia-Jalón [128]	GCP (with HACCP)	Food handlers in contract catering companies	To assess knowledge, attitudes and practices of food handlers within HACCP implementation system in contract catering companies
Jena and Chavan [129]	GLP	(Useful across/within) agro-food product sectors	To explore the use of GLP principles in different fields of science and its acceptability as well as looking forward to its future perspectives
Lepore and Crawford [130]	GLP	(Useful across/within) agro-food product sectors	To view the events that led to need for GLPs, to provide insights into how regulations were prepared and to describe pertinent aspects of some provisions of final regulations
Wolf and Wolfe [131]	GLP	Fish and related products	To use the application of GLP principles to highlight differences between mammalian and fish studies, and help identify with specific concerns associated with formulation of Standard Operating Procedures (SOPs) for fish projects
Lucero and Siñeriz [132]	GLP	Microbiological and related laboratory linked activities applicable to food (and related) sectors	To reveal the Argentine experience in enhancing biosafety through GLPs considering the growing concerns about safe laboratory practices (at the time of the study)
Hart and John Scott [133]	GLP	Fruits and vegetables commonly consumed in the UK	To further examine factors affecting chromatographic response of carotenoids in fruits and vegetables, which contribute to analytical quantitative inaccuracies/variations, by investigating measurement's reproducibility and robustness using a reference (food) material developed in the laboratory
Allwood, Jenkins, Paulus, Johnson, et al. [134]	GRP	Handwashing facilities, and handwashing training in retail food establishments	To investigate the effect of handwashing training, availability of handwashing facilities and ability of the person in charge (PIC) to
Neal, Binkley and Henroid [135]	GRP	Food service workers in retail food establishments at Houston, Texas USA	To identify factors and behavior that constitute food safety culture among food service workers in retail food establishments at Houston, Texas USA
Jame Wyatt and Guy [136]	GRP	Quality of food retail market stores in Oregon, USA	To evaluate the sanitation using profile scoring form as well as microbiological analysis to explore microbial quality of food retail market stores in Oregon, USA
Strohbehn, Sneed, Paez and Meyer [137]	GRP	Hand-washing in retail food service operations industry	To assess compliance with hand-washing regulations with the consideration of frequency and methods used by sectors of the retail food service operations, which involved hand-washing behavior during menu production, service and cleaning
Picha, Skořepa and Navrátil [138]	GRP (and some related aspects)	Food retail chains in Czech Republic	To assess differences in food choice behavior between regular customer of a specific food retail chain compared to another, using a strategy formulated by consumer cooperative in Czech Republic

(*Continued*)

Table 2 (Continued).

References	Good (food hygiene quality safety) practices	agro-food product supply chain and related sector	Specific objective of study
Kungu, Dione, Roesel, Ejobi, et al. [139]	GRP (and other related aspects)	Pork retail outlet in Uganda	To map the distribution of pork retail outlets as well as assess their role in foodborne disease transmission, specifically, practices associated with hygiene related infrastructure, workers and equipment
Ajani and Onwubuya [140]	GSP	Maize storage practices among farmers in Anambra State, Nigeria	To assess the use of indigenous maize storage practices among farmers in Anambra State, Nigeria
Shabani, Kimanya, Gichuhi, Bonsi, et al. [141]	GSP	Maize storage practices in Handeni District, Tanzania	To investigate the maize storage (and consumption) practices of farmers, which included implications for mycotoxin contamination of maize flour in Handeni District, Tanzania
Hell, Cardwell, Setamou and Poehling [142]	GSP	Maize storage practices in four agroecological zones of Benin, West Africa	To determine the effect of storage practices on aflatoxin contamination in (300) maize farmers stores in four agroecological zones in the Republic of Benin, West Africa
Katundu, Hendriks, Bower and Siwela [143]	GSP	Small-scale organic potato farmers in KwaZulu-Natal, South Africa	To investigate the effects of traditional storage practices on the quality of potatos of small-scale organic farmers in rural KwaZulu-Natal of South Africa, based on preference of products comparing conditions over a 6-week period
Martins, de Campos Leite, Martins, da Silva, et al. [144]	GSP	Seafood storage at 21st Supply Deposit of Brazilian Army, São Paulo, Brazil	To evaluate good (seafood) storage practices in the 21st Supply Deposit of Brazilia Army located in São Paulo, Brazil, identify issues of non-compliance that compromise food quality and propose solutions
Uplap, Khandave, Thorat and Lohar [145]	GSP	Food grain storage involving farm women of Pune District (Maharashtra), India	To determine the knowledge and adoption of food grain storage practices by farm women of Pune District (Maharashtra), India
Evans and Redmond [146]	GSP	Domestic food handling and storage practices associated with ready-to-eat (RTE) foods in older adults	To ascertain older adults' cognition in relation to domestic food handling and storage practices that may increase the risks associated with *Listeria monocytogenes* in RTE foods
Balzan, Fasolato, Cardazzo, Berti, et al. [147]	GTP	Fresh and frozen food chain in North East of Italy	To gain insight into ways consumers purchase, transport and store fresh and frozen food in North East of Italy
Ackerley, Sertkaya and Lange [148]	GTP	Food commodities transportation and holding	Using expert opinion elicitation to assess food safety hazards and preventive controls associated with transportation and holding of food commodities

manufacturing processes required to ensure the food production process adheres to the prerequisite safety standards.[47,150] For the reason that every element of food production has to be defined in advance, specific resources have to be delivered in its appropriate place, quantity and time, and utilised as intended.[33]

With respect to agro-food products, the GMP's guiding principle is that the prerequisite quality has to be built into the (agro-food) production schedules through the standard operating procedures (SOPs). Furthermore, the SOPs have to consistently perform under the same (standard) conditions to meet up with the final specifications.[151,152] Globally, the GMP regulations do differ, for example, the FDA in the US was key in setting-up GMP regulations. Other countries, such as Australia, Japan, Singapore, including the EU, have their own GMP regulations. The WHO's GMP regulations apply to many countries that do not have their own GMP requirements.[153] In addition, the GMP is equally applicable to the agro-food products that require refrigeration. In the US for instance, both the GMPs and federal regulations do differ in some specifics, an example, the acceptable upper-temperature

limits of refrigerated food products. In addition, to maintain the organoleptic and quality characteristics can help to realise the significant shelf life extension of the refrigerated (food) products.[32] Within the agro-food product supply chain, the manufacturing facility should be made to adhere to the GMP plant sanitation guidelines. Within the manufacturing process, the GMP is therefore very critical particularly in the product development stage(s).[32]

Besides having the technological capacity to tackle food industry challenges, GMP under the specified conditions can serve as a food process guide.[154] The GMP considers the development, processing, and marketing phases within the food supply chain.[32] Elements of GMPs can include pest control, sanitation procedures, sanitary design and maintenance of equipment/facilities, training in personnel hygiene, and warehousing/distribution.[155] Within the food industry, the GMPs would help to address the factors within the manufacturing process, such as personnel, building, premises, apparatus/machinery, documentation, quality control, that generally influence product quality/monitoring.[152] From the refrigerated foods to the food processing facilities, the GMP effectively monitors the safety components, for example, the microbiological hazards especially in manufacture and distribution.[32,156] In the agro-food processing plants, the GMP manuals would facilitate continuous evaluation and improvement. In addition, the GMP's would help the food industries to adopt measures that guarantee products' conformity as well as safety, in the adherence to the specific regulations.[151]

To implement the GMP procedures in the food industry would require a wide range of general measures, already described by the Codex Alimentarius, which can include: a) hygiene in primary production; b) hygienic design of equipment/facilities; c) control of operations, maintenance and sanitation practices; d) personal hygiene; e) transportation; f) product information; as well as g) consumer awareness/training.[151] Whereas the food industry adopts varying procedures, the hygiene practices continually adhere to general Codex Alimentarius guidelines.[151] Implementing the GMP in the dairy processes is key in reducing the biological, chemical, and physical hazards that contaminate (dairy) products.[151] Implementing the GMP should be seen as a continuous process that is largely based on the PDCA cycle, that is, *P* = Plan, D = Do, C = Check, and A = Action, which would directly relate with the four key steps, namely: a) there should be an initial diagnosis; b) there should be an elaboration of the road map; c) both diagnosis and roadmap will help to address non-conformities; d) the corrective measures under implementation should be subject to a re-evaluation.[97,151,157] Using a GMP regulated checklist, both initial diagnosis and re-evaluation of corrective measures can be implemented through the audit of processing facilities. Likened to a road map, the implementation of GMPs would provide tangible benefits, which could be assessed by key candidates such as microbiological indicators, pre- and post-implementation costs, etc.[151]

The GMP alone or combined with HACCP, etc., was investigated in bakery small-medium enterprises, [96] foodservice kitchens,[98,102] traditional indigenous food production,[97] dairy plants,[99,100] and other food production plants,[95,101] which had a wide variety of outcomes (Table 2). Martinez-Tomé, Vera, and Antonia Murcia[102] used GMP + HACCP to check food production in school kitchens and obtained reductions in the microbial population of examined cutting boards, tables, etc., as food handlers improved in food safety practices. By formulating a strategy for improving food safety through the GMP implementation, Arkeman et al. [96] used the SWOT analysis and were able to identify the significant aspects of supporting elements as well as constraints. The complete analysis brought about the five alternatives formulation strategies, which these authors believed could help in improving the food safety practices based on the implementation of GMP. The five alternative formulation strategies included: a) creating promotional area of healthy safe original (Bogor) foods in a strategic area for (SP-IRT) certified bakery SME products; b) keeping the SP-IRT registration fee waiving policy; c) creating both local food-nutrition strategic action and industrial development strategic plans; d) creating a planned training program for food safety extension workers and control personnel; and e) conducting periodic annual control. In another study conducted in Ghana specific to the traditional production of kenkey, Amoa-Awua et al. [97] reported that GMP was applicable in the management of mycotoxin contamination of maize (and maize products). The application of GMP

(and HACCP) was found effective in assuring the quality safety of kenkey in the traditional processing of maize into kenkey. Santana et al. [98] sought to establish how adopting GMP could assure safe food supply to students, and this was conducted by evaluating food safety services used in free school meal preparation. The results, based on a checklist survey, showed that about 80% of the food safety services prior to adopting the GMP were classified as 'poor'. Therein, the samples measured for microbial analysis that showed high aerobic plate count (APC) as well as the presence of thermotolerant coliforms and *Staphylococcus* TNase-coagulase positives. By adopting the GMP procedures, the schools could achieve higher survey scores, together with the respective reductions in quantity of APC, (thermotolerant) coliforms in the meals, as well as the non-isolation of *Staphylococcus* spp.

By assessing both hygiene and manufacturing practices, Rodmanee and Huang [95] reported that a community (herbal product) enterprise in Thailand fell short of its required GMP standard. It was to tackle this situation that an action plan that considered the participation of every stakeholder was developed. In a Poland study that sought to decipher the status of GMP and its related rules, Konecka-Matyjek et al. [102] found that whilst some food production plants were in the process of implementation, others were still thinking of doing so. Moreover, Bernhardt and Raschke[94] delineated useful benefits in the sugar factory by introducing GMP. Examples of such useful benefits included the reduction in waste as well as enhancement of profit revenues. Of course, there are aspects of GMP that could be applied in developing, processing, and marketing refrigerated foods to improve ingredients, product development, processing, storage, and distribution of refrigerated foods.[32] By combining GMP, HACCP, and other related ones, Demirbaş and Karagözlü [100] surveyed the level of food safety (compliance) in dairy plants in Turkey. These workers showed that the food legislation would likely suffice, especially to ensure the compliance with food safety procedures. But not all the dairy processes had incorporated the government-imposed regulatory practices. However, technical support was suggested as needed to enhance the food safety infrastructure for the dairy industry. Similarly, Cusato, Gameiro et al.[99] showed GMP (+SSOP, etc) implementation resulted in a significant reduction in yeast and mould count in the dairy processing plant. Additionally, the feasibility of small-scale food industries to implement such food safety systems was delineated at that study.

Good hygiene practice (GHP)

GHP guidelines specify that the hygiene activities have to be continually monitored at all the food supply chain processes as well as stages.[47,150] In addition, the GHP guidelines would constitute (some) practical procedures that should help to return the processing environment to its original condition (disinfection and sanitation programs).[42] In addition, the GHP has general principles, which have been linked to food hygiene, as legislatively underpinned by EU Regulations No: 178/2002, No: 852/2004, No: 853/2004. No: 854/2004 as well as Codex Alimentarius.[127] In addition, the GHP has an exhaustive list of measures prerequisite to other food quality and safety management systems.[158] Under the EU hygiene regulation directive, the GHPs indicate the consumer has a direct food safety responsibility. This has allowed the food industry to possess some form of flexibility, so as to meet up with the obligations, through the use of the more appropriate prerequisite approaches and standards.[159] In order to ensure food hygiene from farm to fork, the GHP gives a great deal of emphasis to the hygiene control, especially at each stage of the food supply chain.[160] Regardless of the location/settings, to adapt the GHP requires sufficient information about specific food handling, preparation, and storage procedures that would reduce the food hazards/risks.[161] GHP, especially in the food industry, provides the conditions/measures required to control hazards that make foodstuffs fit for human consumption.[158] Besides GHP controlling food safety risks,[156] the concerns of cross-contamination continue to be among the key challenges for GHP.[161]

GHP's compliance helps to increase the awareness of food microbiological challenges.[162] If the food industry/sector management takes GHP seriously, provides the time/resources, and makes available the rewards for good performance, the employees would most likely emerge more diligent in their responsibilities. The GHP can, therefore, take the form of an appraisal system, especially for

employees, supervisors, and managers. While the GHP violations should be handled in a disciplinary fashion, there should be some form of incentive put in place as a reward to the high-level (GHP) performance. In addition, developing and monitoring the hygiene procedures with the staff can serve as an effective means of winning (staff) commitment.[159] In the process of applying the GHP, it is necessary that both storage and pre-storage practices be prioritised as this remains very key if the contamination problem is to be reduced.[93] In this way, the GHP can serve as a positive influence on the wholesomeness of food, as well as ensuring the optimal hygiene condition of (food) production processes.[163] In meat processing, for instance, the GHP posits as a hygiene-based on-farm measure to control interventions. The GHP can also be applied at multiple points within the (food) supply chain, and implemented in cycles resembling a sanitation-like activity, which concurrently runs with the application of sanitisers.[93]

The GHP framework can take the form of either a brochure or manual , which should be an easy-to -read as well as easy-to-understand document especially for the local (farmers/industry/supply) chain workers and consumers. From this approach, the awareness about cross-contamination is increased, particularly to the benefit of the agro-food product industry.[162] The GHP lays this foundation, especially in handling and storage as well as inspection of incoming materials, which would ensure that the production plans, together with the suppliers' specifications can be met.[93] For long, the periodic assessment of food hygiene training and subsequent checks especially for the managers has been a standard requirement, [164] which has ensured the knowledge update(s) about the food hygiene practices continue got provided. As an example, the street food vendors need to be continually informed about GHP especially at all the stages of the production chain.[113] Therefore, the GHP applied within the foodservice requires some form of verification, which has to be conducted using a checklist approach.[127] In Uganda, for example, the GHP served as a candidate used for quality assurance rules, which formed part of the fish safety compliance and standards, which has helped to improve product quality safety.[165] In line with this, the design and layout of food retail/industry premises should allow for the GHP implementation. Further, the internal structures and equipment should therefore be built of materials that allow for easy cleaning, disinfecting, disinfecting, and maintenance.[166]

GHP alone or combined with GCP, GSP, HACCP, etc. investigated food handlers, [108,110,114,115] specifics like meat handlers, [105,107,112] different food (service) establishments,[111] like retail (meat) shops, [109] food truck, [103] food vendors,[106] urban street food sellers[113] and foodservice facilities[104] with variable outcomes . Ifeadike et al. [110] assessed the food hygiene practice of food handlers in the FCT Nigeria, and found that majority washed their hands after using the toilets and underwent regular medical checkups, with much less (food handlers) either using disinfectants and sanitizers or checked the food temperature with a thermometer at the workplace. In another study, Saad, See and Adil [108] assessed the level of food hygiene practices of food handlers in the Northern Region of Malaysia. These workers found the food hygiene practices to be consistent with the requirements of the Food Act 1983 and Food Hygiene Regulation 2009, which demonstrated that food handlers were very important key players in the GHP implementation particularly within the foodservice industry. Indeed, when the food handlers become familiar with the foodborne diseases and they are able to highlight the preventive measures, it is likely to reflect on their personal hygiene status. This makes formal training (of good hygiene practices) [114] as well as consistency in work experience/ exposure to food handling [108] very essential. Upadhayaya and Ghimira [109] reported that the majority of meat handlers had no regular health checkups and demonstrated the knowledge gap about the Slaughterhouse Meat Inspection Act 1999 of Nepal. Implementing this (food hygiene) regulation would play a crucial role to improve both the hygiene practices and quality standards of the meat products/shops. Rahman et al. [106] assessed the level of attitude, knowledge, and practice of food safety, and reported both age and ethnicity as important factors for food safety knowledge, which altogether would influence food safety practice. Jianu and Goleț [105] determined the knowledge of food hygiene and safety in the meat processing unit in Romania and reported meat handlers deficient in identifying both chemical/microbiological hazards and hand hygiene aspects. Significantly, the level

of (food hygiene and safety) knowledge correlated positively with the practice of meat handlers. Training programs with an emphasis on the identification of risks to food safety and hand hygiene were recommended.

Okpala, Nwobi and Korzeniowska [112] assessed the butchers' knowledge and perception of GHP and good storage practices (GSP) using a cattle slaughterhouse case analysis. Their findings revealed that butchers were male, with more than 5 years of slaughterhouse experience, and strongly familiar with GHP and GSP. Further mentioned in that study, butchers were able to provide examples that demonstrated knowledge and perception of GHP and GSP. Additionally, the perception aspects of GHP and GSP were correlated more, compared to knowledge and knowledge versus perception. Kunadu et al.[115] evaluated the food safety attitude, knowledge, and practices in foodservice establishments. These workers reported the food handlers' attitude towards the food safety as generally negative, raising such concerns like a) lack of knowledge of contaminants/contamination; b) lack of knowledge about appropriate holding temperature; c) poor food hygiene safety practices; and d) infrequent handwashing during food preparation either after coughing or sneezing. To alleviate this challenge, these workers recommended the need for continuous risk-based training to educate and effect behavioural changes among food handlers. Such training would bring about a positive attitude towards food safety and as a consequence, promote the overall good (food hygiene safety) practices. Baluka, Miller, and Kaneene [104] examined individual workers and institutional practices in foodservice facility and reported the (foodservice) personnel with higher education levels showed the better attitude/knowledge of food safety, although the latter did not corroborate with the microbiological acceptability of food samples (at the foodservice facility). Regards to the food vendors, Djekic et al. [111] associated the major differences in food hygiene levels in food establishments with HACCP (implementation) and not with size and type of establishment. In another study, Cortese et al. [113] reported the usefulness of specific local and national food laws in protecting consumers and ensuring continuous training of food vendors so as to address the inadequacies of food quality and safety. Investigating GHP implementation in food trucks used for food distribution, De Lima et al.[103] reported that increases in food safety awareness would help food truck owners and staff to value investing in food safety, which would ensure an effective reduction of contamination risks.

Good agricultural practice (GAP)

GAP was first started in 2003 by FAO.[160] The FAO referred GAP as practices that address economic, environmental, and social sustainability for on-farm processes to bring about quality and safe food (and non-food agro-products).[167] As a selection of methods of land use, GAP can best achieve a number of agronomic and environmental sustainability objectives in primary food production.[42] According to US FDA, GAP aims to reduce the possibility of microbial contamination associated with such practices like the application of raw manure, contaminated agricultural or processing water, unhygienic practices by farm holders and workers, as well as poor sanitary facilities.[168] GAP is considered among essential good practices especially to curtail hazards that make their way through the food supply chain.[160] In recent years, GAP codes, standards, and regulations have developed for a wide range of commonalities so as to codify agricultural practices even at the farm level. Some objectives of GAP codes, standards and regulations can include: (a) Ensuring quality safe food chain produce; b) Capturing new market advantage via governance modification of supply chain; c) Improving worker health, working conditions, and natural resource usage; d) creating new market opportunities for farmers and exporters, especially in developing countries.[160]

Originally, the criteria to define GAPs were developed for on-farm production methods and resource use. Recent years show that organisations would promote voluntary private standard (PS) schemes and apply them across the agri-food supply chain.[169] With the growing concerns over food quality, safety and sustainability among consumers, retailers, governments, processors, as well as growers, the GAP would serve as an effective measure that ensures, not only the quality/safety of products but also create a number of new market opportunities that improve the farmworkers' health

and working conditions [168] Four pillars that represent GAP can include: a) economic viability; b) (agricultural) environmental sustainability; c) social acceptability; and d) food quality/safety. GAP can also have the following objectives: a) ensuring food safety; b) building consumer/customer confidence; c) capturing new market; d) judicious use of natural resources; e) maintaining worker health and welfare; f) income generation; g) enhancing international trade; and h) risk assessment.[168]

The GAPs, through the use of Codex Alimentarius Commission's code of practice for fresh fruits and vegetables (CAC/RCP 53–2003), would involve all activities in and around the agro-food farm fields before, during and after harvest/production (that is, water quality, personnel hygiene, manure composting, etc).[170] GAP can be harmonised with food safety standards within a given supply chain, which would allow for audits by a credible third party acceptable to all produce buyers, so as to reduce the audit burden on growers.[168] Through agricultural practices and management systems linked to microbiological contamination of lettuce in conventional production systems, Bartz et al. [171] considered GAP as among food safety management systems, which at the farm level would reduce/prevent bacterial contamination of fresh produce. Despite this, GAP ought to be conducted in a step-wise manner, and based on the risk associated with individual fruits and vegetables, and available scientific data.[117] Despite the voluntary nature of GAP certification and its compliance among foodborne pathogen decontamination strategies, the use of audit structures across small-scale farmers might still appear low, which makes (GAP) food safety principles yet to gain traction.[116]

From Table 2, the GAP studies investigated vegetables[142,143,144,145,146] but could also apply to specifics like tomato production [118] or broader, like fresh produce[116] and produce plant(s),[117] which resulted in various outcomes. At a greenhouse growing pepper and tomatoes in Greece, Kokkinakis et al. [120] showed that the GAP protocol AGRO 2–1 & 2–2 could reduce the microbial hazards for consumers and help establish practices in compliance with the basic Euro Retailer-produce GAP (EUREPGAP) requirements. At a vegetable production in both Delaware and Maryland of USA, Marine et al. [121] reported that implementing the GAP might not necessarily bring about differences in food safety practices with respect to farm-scale or production year, and economic constraints might not also be considered an obstacle. Conducting investigations involving the Minnesota USA vegetable farms, Hamilton et al. [122] demonstrated that incorporating GAP measures would help to reduce the risk of domestic/wild animals' entry into the fruits and vegetable areas. In another study, Nurul Islam et al. [118] revealed large-scale tomato farms in Malaysia that utilised GAP practitioners obtained improvements in both income and productivity compared to non-GAP ones. Indeed, the GAP was found an effective candidate, although not completely so considering that the small-scale farmers still encountered a number of constraints, for example, the lack of access to credit for investment as well as technical support. Recommendations like extending, monitoring, and upgrading of Malaysian certification were suggested as possible way out to help assure the product quality. Other workers like Wongsprawmas, Canavari and Waisarayutt[119] understood that consumers' demand for fresh vegetable production could help promote the GAP adoption to producers in Thailand. In another study that involved the fresh produce farms at Commonwealth of Kentucky USA, Sinkel et al. [116] opined that even when the majority of (fresh produce) growers were familiar with GAP, the additional education was essential to advance their understanding of food safety practices. Based on a food safety checklist, da Cruz, Cenci, and Maia [117] evaluated the GAP of Brazilian produce plants and reported the production units did not conform to the GAP program items. Therefore, a corrective action plan was deemed necessary, in order to improve both quality and safety of (obtained) raw produce. By studying the smallholder vegetable farms across Trinidad of West Indies, Ganpat et al. [123] established that, in the situation where the compliance to GAP appeared low among the farmers, to produce high quality and safe vegetables would pose a challenge, and require better-educated extension service for improved GAP compliance.

Good storage practice (GSP)

GSP involves the practical procedures/processes that ensure the appropriate handling of foods, regarding the implementation and control of the product storage consistent with the defined regime-(s), and prior to their use.[42] Applicable to a wide range of sections/units, the GSP should consider all measures of distribution and storage of food products to sustain its intended nature/quality to a large degree when it reaches the consumer. GSP components can involve components like documentation, personnel, stock management, storage facilities, etc. Specifically, for storage to meet the needed requirements, the respective areas have to be assigned as the sampling of products, dedicated to the specific product conditions, and differentiated based on the specific product categories.[172] The storage environment should have prerequisite monitoring points, in addition to the effective humidity and temperature control measures. Specifically, the temperature requirement of the storage environment must comply with the labelling standards, without any compromise to the quality/safety of (food) products. In food control (sections/units), storage systems should systematically provide sufficient passage for inspection and easy movement given by proper labelling and product release mechanisms.[172]

GSP can also interact with both GAP and GHP, and a schematic representation showing this interaction as applicable and relevant to a typical cattle slaughterhouse in Nigeria is shown in Fig. 4. Specifically, each of these good practices have reflect very important aspects of the typical cattle slaughterhouse. For instance, GAP will involve the arrival of cattle to the slaughterhouse, and in good condition. Then, GHP will involve the slaughter preparation, the actual slaughter process, and subsequent carcass handling thereafter. Then, GSP will involve all aspects of carcass storage, distribution, as well as refrigeration. Additionally, GAP will involve the cattle rearers, whereas GHP and GSP will involve the slaughterhouse activities. The interaction of GAP, GHP, GSP demonstrates the importance and relevance of these practices to the typical (Nigeria) cattle slaughterhouse, [112] and that is why it is deemed the compulsory (hygiene/safety-related) aspects of QM. Besides, the personnel that operate within the food storage section must have the

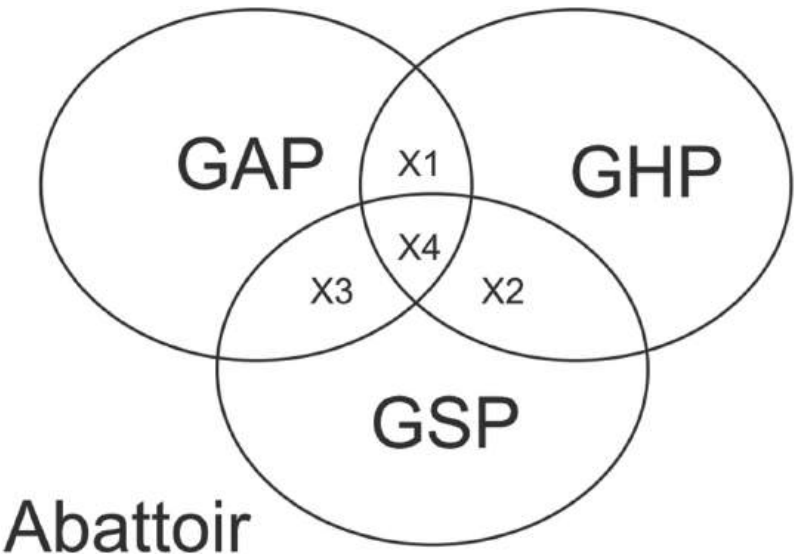

Figure 4. Schematic representation of the interaction between GAP, GHP, and GSP applicable and relevant to a typical cattle abattoir/slaughterhouse in Nigeria. GAP = Good Agricultural Practice, which can involve the humane handling of cattle as well as pre-slaughter keeping of cattle at lairage; GHP = Good Hygiene Practice, which can involve slaughtering activity, as well as carcass splitting and inspection activities; GSP = Good Storage Practice, which can involve carcass storage and refrigeration; X1, X2, and X3 represent the interactive spaces of GAP x GHP, GHP x GSP,, and GAP x GSP, respectively. Additionally, X4 represents the interaction of GAP x GHP x GSP (Source: Okpala, Nwobi & Korzeniowska [112])

experience and should be able and healthy. They should be in a sufficient number so as to avoid exhaustion/overwork. The GSP training can range between basic (storage management/safety hygiene) and specific (computerized stock management) aspects, inclusive of documentation procedures and control systems. The GSP makes written procedures available for returned (agro)food products, which enhances investigations/evaluations of quality and safety, via labelling and segregation of returned goods. Similarly, there is the food products' disposal that involves the written procedures, especially how it should be handled, and consistent with the company and country regulatory requirements.[172] Besides, the organizational workplace should be held to very high discipline and standards, so as to avoid as well as minimise customer complaints of food product(s)/service(s). When such complaints emerge, however, there must be careful and thorough investigation consistent with the laid down procedures. In addition, the responsible person handling the complaint/matter should possess adequate knowledge as well as experience, and importantly, the authority to decide the measures to take/be taken.[172]

In the agro-food product industry, the GSP provides the platform to classify defects of (food) products, namely: minor, major, and critical defects. Whilst the critical defects are those products that are deemed spoiled and require immediate action, the major defects are when the product does not conform to the required standard, whereas the minor is such that there is no important effect, e.g., lack of labelling.[172] In addition, the GSP provides the platform for food product recall, where the responsible person either removes and or withdraws a particular food product from the distribution chain/line. The removal and or withdrawal (of food product) may be due to central quality defects with potential consumers' health risks of the foodborne pathogen. In addition, the GSP provides the platform to recognise various food production staff and their corresponding duties/responsibilities. The quality control manager has to be responsible for assigning qualified recall teams to develop recall strategy.[172] From , GSP studies investigated farm maize storage, [140–142] food grain storage of farm-women,[145] traditional storage practices of small scale organic potato farmers,[143] food handling and storage practices associated with ready-to-eat (RTE) foods,[146] and seafood storage at a supplied deposit, [144] which has reported various outcomes.

Assessing farmers' use of indigenous maize storage practices in Anambra State-Nigeria, Ajani and Onwubuya [140] reported farmers used indigenous technologies such as basket, bare floors, among others for storing the maize. The use of materials free from termite, clearing surroundings against fire disasters, as well as the use of durable materials treated with insecticide, helped to tackle the maize storage challenges. In addition, an appropriate and affordable storage structure was deemed necessary for the maize farmers to avoid the produce wastage during the storage periods. Hell et al. [142] studied the storage practices' influence on aflatoxin contamination in maize in four agro-ecological zones in the Benin Republic. The results showed those cultivated in the Southern Guinea and Sudan Savanna, were associated with higher aflatoxin levels. Further, lower aflatoxin levels resulted when storage or cotton insecticides, mechanical means or smoke to protect pests, or cleaning of stores before loading them with new harvest were applied. Shabani et al. [141] investigated the maize storage and consumption practices of farmers in Handeni District, Tanzania, and reported the majority of farmers (95%) stored the maize in the house using roofing and sack methods. Insects and rodents were among storage challenges. The preponderance of storage practices was considered unfavourable to mycotoxin reduction in stored maize. Area-specific farmer training regarding recommended storage practices includes storage methods, effective management of storage pests, healthy maize preparation, and consumption practices.

Studying both knowledge and adoption of food grain storage practices in Pune District (Maharashtra), Uplap et al. [145] found the majority of farm women adopted the method of sun-drying followed by the method of separation of infested food grains, followed by the method of sieving food grains, and followed by the method of separation of broken grains. Investigating the traditional storage practices on small-scale organic farms, Katundu et al. [143] found the sensory panelists' significantly preferred the in-situ stored potatoes over those stored in both the farmer's house and

controlled storage. The in-situ storage would desirably maintain the sensory properties of potatoes, by sustaining the low sugar levels and high starch content. Investigating the storage practices of ready-to-eat (RTE) food products and risks associated with listeriosis, Evans and Redmond [146] reported that, despite 79% of older adults having positive attitudes towards the refrigeration, about 84% appeared unaware of recommended temperatures (5 °C). Also, about 72% knew that the 'use-by' dates indicated food safety, whereas about 67% considered it safe to eat food beyond 'use-by' dates. Older adults, although knowledgeable of some key (storage) practices, self-reported potentially unsafe practices when storing RTE foods at home, which may increase the risks associated with *L. monocytogenes*. Assessing the frozen seafood good storage practices in the 21st Supply Deposit of the Brazilian Army, Martins et al. [144] found that the cold stores' temperatures could not sustain the (seafood) products within the required preservation standards. The seafood storage protocol (of 21st Supply Deposit) appeared not able to guarantee the conformity of the temperature. Implementing the hygienic-sanitary self-control storage program was suggested, in order to improve the food safety culture, which would involve applying a checklist (RDC 275/2002) that evaluates the percentage compliance with good practices.

Good catering practice (GCP)

GCP consists of practical procedures in catering, essential steps required to ensure food served is always safe and wholesome.[42] Within food safety and quality assurance, GCP forms part of food processing, having practical catering procedures. GCP guidelines focus on essential steps required to ensure the food served remains safe and wholesome.[41,160] Given that the catering and retail go together within the food supply chain, the relevance of GCP must not be taken for granted.[162] GCP within kitchen processes in the restaurants and food/beverage companies brings together food and drink processes/transfers, including diverse related production units. In batch cooking of catering companies, GCP can employ some aspects of GMP, especially for the large (food) catering processes. As such, hygiene, quality, and safety procedures/systems, as well as legalities guarantee the assurance of food safety.[173]

When GCP forms a part of a certification framework, the certificate holders will have benefits such as a) strengthening of the public image of the individual/company; b) competitive advantage (within the catering sector); c) demonstrable evidence of working under hygienic conditions; d) strengthened food security across employees; e) ability to fulfil the legal requirement as per food standards; f) strengthened consumer's image to food company/employer; g) increased work efficiency within the catering/food industry; and h) motivated employees within the catering/food company.[173] In large catering processes, GMP implementation has always been deemed mandatory. Through this, GMP is able to provide the essential foundation for the efficiency of important food safety catering standards. To consumers, the GCP certification demonstrates a commitment to producing quality safe food. Such certification provides a comprehensive and cost-effective approach in developing a successful food safety management system (FSMS), which is compliant with the food safety regulations.[174]

The GCP studies alone or combined with GHP, HACCP, etc., shown in , which investigated food handlers in the canteens/restaurants,[124,126,127] catering companies[128] or both (that is, restaurants and catering companies combined),[125] showed varying outcomes. Evaluating canteens' level of attitude, knowledge, and practices of food hygiene and safety in a Malaysian university, Nee, and Sani [126] reported that food handlers possessed a good knowledge of personal hygiene. By defining foodborne disease, the food handlers were shown to possess a positive attitude towards food hygiene/safety. It also demonstrated their ability to control/prevent foodborne diseases. In another study, Veiros et al. [127] reported the canteens within the acceptable range given by a global score of 62% based on the food hygiene quality checklist of Portuguese and European legislation used in verifying practices/procedures related to HACCP prerequisite. Food handlers in that study required improvement, especially in the preparation and distribution of foods, as well as

the cleaning, and quality control aspects within the canteen facilities. Food hygiene/quality checklist could improve quality control of food production in catering establishments, especially hygiene and sanitary quality of meals. Detecting the most important knowledge gaps about food safety in catering and restaurant companies, Pichler et al. [125] reported the food handlers that undertook the annual training were found to possess a higher (food safety) knowledge. Even with the annual training, there would still be some substantial knowledge gaps, for example, the correct temperature for cooking, holding, and storing foods. In restaurants in Salvador – Brazil, Rebouças et al. [124] reported that even though food handlers possessed relatively high attitude, knowledge and practice of personal hygiene, it would not be so for both chefs and managers as their knowledge might fall short, even when majority possessed food safety training certificate. Garayoa et al. [128] revealed that, in a good number of kitchens in some Spanish catering companies, when incorrect hygiene practices became systemic, to implement the HACCP system presented inherent difficulties. These were corroborated by the lack of well-trained personnel and the lack of motivation of workers. Such inherent difficulties could however be tackled if the adequate educational programs and funded grants were to be provided towards actualising the HACCP implementation.

Good laboratory practice (GLP)

GLP was first presented to FAO Committee on Agriculture in 2003 as an official regulatory concept that involved a qualitative system, as well as governing organisational conditions/processes within the prerequisite analytical-oriented framework, which would allow for the monitoring, performing, planning, recording, and reporting studies [28,42] Specifically, the object of GLP is to promote both the quality and validity of test data, which arose as a result of the concerns of the validity of non-clinical safety data, which had been submitted to the FDA, at those earlier times.[28] All processing/testing methods and the corresponding equipment/facilities that required the standardisation and validations underlined the core of GLP, which is based on the scientific principles and practices.[175] Regulatory agencies like FDA and US Environmental Protection Agency (EPA) require that the conducted (analytical/laboratory-oriented) studies accord with the GLP. Further, the GLP principles of the Organization for Economic Co-operation and Development (OECD) apply to all OECD countries.[175]

Evaluating the GLP-related safety procedures should include a systematic weight-of-evidence as well as framework-like review, which considers such (evaluation) factors like a) verification of measurement processing data and methods; b) control of variables that could affect the food (production) measurements/processes; c) corroboration among studies (applicable to the situation of food-related studies); d) power (both biological and statistical); e) biological plausibility of results; and f) uniformity among (food) substances with resembling/similar attributes and effects.[175] Quality control procedures, quality assurance reviews, and facility inspections employed would help to enforce as well as monitor the GLP compliance. In addition, the detailed processes of GLP among others aim to provide the regulatory agencies increased confidence, particularly to authenticate both the quality and relevance of safety decisions.[175] Besides, the GLP employed in the laboratories, would form the backbone of various experimental studies.[176]

From Table 2, the GLP studies are shown to involve fish and related products, [131] fruits and vegetables (commonly consumed in the UK),[133] microbiological and related laboratory activities (applicable to food and food-related sectors)[132] as well as those applicable to a wide range of agro-food product sectors.[129,130] Jena and Charan [129] showed that the GLP can broadly apply to any relevant discipline in science, to cater to the demands/needs of experimental objectives, generate quality data as well as facilitate reproducibility. To enhance its international acceptability, the GLP has shown a useful way of promoting the reliability and reproducibility of text-related data. With respect to fish and related products, Wolf and Wolfe [131] showed the GLP principles could highlight differences between fish and mammalian studies. These workers found merits in adhering to GLP as it helped in developing the study-specific 'Project Sheet', which would contain all the instructions not

spelled out in the study protocol. This study-specific 'Project Sheet' would thereafter serve as an ad-hoc version of standard operating procedures (SOPs). With respect to fruits and vegetables, Hart and John Scott [133] understood that experimental factors could affect the validity of data, for example, 'peak response' specific to their experiment, which likely contributed to the 'between' and 'within' laboratory variations. Both the development and use of standard reference materials were suggested as useful candidates that can significantly improve the data quality. With respect to microbiological and related laboratory activities, Lucero and Siñeriz [132] showed GLP training courses (applicable to food and its related sectors) could help bring about useful change in work habits, improve laboratory work safety, and overall, motivate work. Whilst the microbial laboratory personnel require training, especially in the proper use of experiments and procedures, it is essential that (national) institutes continue to strengthen the networking effort, so as to increase the (laboratory-oriented) capacities. According to Lepore and Crawford, [130] GLP program instituted by FDA was purposed to ensure the integrity/quality of (submitted) safety data, particularly towards the approval of regulated products, e.g., food additives. GLP program at that time, regulations were hoped to increase public confidence, especially in the FDA decision-making, so as to ensure the safety of products approved for the consumer market.

Good retail practice (GRP)

GRP involves the practical procedures and processes that ensure the delivery of requested/right product(s) to the correct addressee within a satisfactory time period and at the required conditions. This would employ tracing systems that detect faults, to enable an effective/efficient recall procedure.[42] Well-known to occupy a great portion of the agro-food product industry, the retail sector increasingly holds multimillion-dollar food chains.[177] Given the localised nature of food production, the GRP is largely seen to portray a 'closer' connection with the point of production that supports the local economy. Food produce supply can be either direct channel, e.g., farm shops, local retailers, e.g., bigger farm as well as specialist food outlets, or those located outside the locality, readable via online food retailing. Besides serving as an essential aspect of consumer society, food-shopping provides a useful base for consumption/production in the agro-food product sector.[178]

GRP involves the risk categorisation of retail food establishments, which can range between risk type 1 (pre-packaged, non-hazardous foods only), risk type 2 (limited menu involving 1 or 2 menu items), risk type 3 (extensive handling of raw materials specific to a variety of process requiring cold & hot holding of potentially hazardous food), risk type 4 (extensive handling of raw ingredient to advance preparation of next day service), and risk type 5 (extensive handling of raw ingredients specific to food processing at the retail level).[179] GRP crucially aims to maintain the required level of food safety, particularly in the food retail industry/sector. This is understood to happen through the following categories: a) certification and training of managers; b) cleaning and sanitation practices; c) food storage conditions; and d) temperature and time controls .[179] Considering the food retail establishments/units, there are operational activities that (field) experience/research identified capable of producing incidence and severity of foodborne pathogens. These activities include those: a) related to sourcing (food from unsafe sources); b) related to processing (inadequate cooking, improper holding time/temperature); and c) related to cross-contamination (contaminated equipment; poor personal hygiene).[179] In typical meat and related retail unit, the GRP would cover eight key areas, namely: a) receiving the meat product; b) storage of meat product; c) fabrication of meat retail facility; d) ground type of meat product and its aspects; e) sausage type of meat product and its aspects; f) processing of the meat product; g) packaging of the meat product, and h) displays of the meat product on the shelf. Each of these areas can constitute some sub-sections, e.g., receiving the meat product can include approved labelling/packaging, meat product inspection, sanitation/pest control. Storage aspects can also seen as another example, which can include storage condition/temperature, box placement, shelf life, cooler and freezer facilities, etc.[179]

From Table 2, GRP (and related) studies investigated sanitation quality of food retail chains/stores [172,173]specific like pork retail outlet, [139] food service workers in retail food establishments, [134,135] and handwashing service industry, [137] which reported various outcomes. To assess the retail foodservice industry's compliance with handwashing regulations, Strohbehn et al. [137] identified some questions that may well arise from the handwashing activities, that is, when hands should have been washed, when hands were washed and how hands were washed. Apart from the differences in the overall compliance with food code recommendation for the frequency in handwashing during production, process service, as well as the corresponding cleaning phases, these workers proposed a benchmark for the number of times hand-washing should be carried out by each foodservice sector during each operational phase. Jame Wyatt and Guy [136] used a sanitation profile scoring form as well as microbiological analysis to evaluate the sanitation of food retail stores in Oregon USA. Whilst certain deficiencies were shown in the sanitation profile, the measurement of sanitary conditions appeared consistent and objective. However, there appeared no correlation between the microbiological quality of products processed at retail stores and total sanitary profile scores. Neal, Binkley, and Henroid [135] investigated the behaviour of foodservice workers within retail food establishments at Houston-Texas and deduced both management commitment and worker food safety were two important behaviour factors for developing a food safety culture. Creating a work environment that encouraged good food safety behaviour/culture could help to reduce the risk of a foodborne disease outbreak. Allwood et al. [134] investigated how food establishment workers in Minnesota were compliant with handwashing procedures. Whilst roughly half (52%) of persons-in-charge could describe the food code handwashing procedure, a bit less (48%) could demonstrate code-compliant handwashing. Besides, a significant association existed between correct handwashing demonstration, physical infrastructure for handwashing and training methods. To improve handwashing practices among the studied (retail) food workers would require interventions that addressed both knowledge of handwashing procedures/requirement as well as development/implementation of effective hand washing training methods. Kungu et al. [139] assessed hygiene practices of pork retail outlets in Kampala district, Uganda, and found over half of pork retail outlets were not authorised to perform slaughtering because meat inspection was not carried out. However, there was a significant association between good hygiene and the presence of public health certificates. Possessing public health certificates was considered an important predictor of good (retail) practice. Picha, Skořepa, and Navrátil [138] assessed the strategic orientation on regional and local products in food retail. The orientation on local and regional products were found the strongest factor that differentiated customers of food retail chain from another elsewhere, which explained about 41% of the variance. Other differentiating factors would include environmentally friendly production sales as well as the quality of food.

Good transport practice (GTP)

GTP involves practical procedures that ensure these are the proper organization, implementation, and control of food products' transport from the producer to the final user.[42] GTP is strictly dedicated to the transport of designated/marked for food use only. Further, the bulk food transported in containers should be reserved for food transport unless the HACCP principles deemed the dedicated transport below the required food safety level. GTP also involves documentation records, e.g., cleaning certificates, food transportation unit number, previous load registration, and temperature/time recordings.[179] All food transportation salvage/spoilage must be handled using the appropriate standards, e.g., itemising/discarding all potentially hazardous food items, food products compromised by the integrity of the package, chemical contamination, etc. All the food products salvaged for human consumption warrant approval by the regulatory authority prior to resale.[179]

The design of GTP considers not only if the food is ready for consumption but also if the conditions for (food product) transportation would introduce, support, or increase hazard at the loading, during transportation, or unloading stages. The adherence to the GTP by the food industry helps to reduce the potential (food product) transportation hazards.[179] The GTP hazards can be categorised, like: a)

hazards related to the food transportation unit, for example, the unsuitability of construction material as well as residues from/of previous cargoes and cleaning/sanitising materials; b) hazards related to loading and unloading, for example, food product transportation temperature increases/decreases as well as the undesirable introduction of microbes or other forms of (physical) contamination; and c) hazards (directly) related to transport, which can include temperature control malfunction and leakages of cooling/heating fluid(s).[179]

The GTP ensures the food products that require prerequisite temperature control are those transported without any compromise to food safety. Refrigerated foods require 4°C or less, and throughout the trip, vehicles should be capable of maintaining the temperature range of between –1 and 4°C. When temperature errors emerge, food product manufacturers must be notified, so as to initiate the special handling procedures, applicable to frozen foods that require minus 18°C or less to preserve (food) quality safely.[179] Proper loading and adequate air circulation must therefore be prioritised, to prevent certain sections of the load attain to a higher temperature compared to the air supplied or returned to the refrigeration unit. This is why the regular monitoring of the air temperature within the (temperature-controlled) transportation unit remains very vital. For the sake of food quality safety, long-distance transportation particularly those of over four hours require documentation using either electronic and or written temperature records within the transportation unit, which thus warrants that the inspection strategy has to be readily available.[179]

The construct and design of a food transport unit should be in such a way that it can eliminate any accessibility constraints, especially in preventing insect infestation, facilitating inspection procedures/processes, providing the appropriate temperature control levels, and reducing cross-contamination.[179] Only the non-toxic and inert (inner) surface materials deemed suitable for direct contact with food should be recommended, e.g., stainless steel or surface(s) coated with food-grade epoxy resins. To reduce contamination risks, the accessories, connections, cleaning/disinfecting and maintenance of food transportation units should be conducted routinely and recorded. All disinfection and rinsing, for example, should be consistent with the manufacturer's instruction.[179] Considering transportation container sanitation, apart from traceability and temperature control, there is international guidance (US-based) related to food safety in the transportation processes, which include International Food Standards via Codex Alimentarius, the US FDA, The Sanitary Food Transportation Act of 1990, and The Food Safety Modernisation Act (FSMA). Besides, to assure quality in food safety transportation, the concepts of internal/external audits as well as continuous improvement should be prioritised.[180] In addition, system management and record keeping are among the key essentials of GTP. Specifically, system management in the GTP context of food safety would consider costs of food safety (and its classification), set of management goals/targets to be achieved, ensure that transit temperature is in control, as well as adherence to tarmac time targets.[180] Moreover, the HACCP plays a vital role in the GTP, especially in preventive control and its (GTP) implementation. Preliminary HACCP plans in the GTP context would involve food safety transportation goals, considering elements like HACCP support team, training, identification of hazards, CCPs, monitoring procedures, corrective action, implementation of standards, documentation/record processes, etc.[180]

From Table 2, GTP studies investigated food commodities transportation/holding [148] and fresh/frozen food transportation, [147] which reported various outcomes. Regarding food transportation safety and by characterising both controls and risks through the help of experts, Ackerley, Sertkaya, and Lange [148] obtained five food safety hazards across the modes of transport, which were considered of greatest concern based on the frequency and severity risk rankings. They included the following: a) lack of security; b) improper holding practices for food products awaiting inspection; c) improper temperature control; d) cross-contamination and e) improper loading practices, conditions, or equipment. Raw seafood, raw meat and poultry, refrigerated raw and RTE foods were found to hold the highest overall risk (in descending order) across all modes of transit. On the other hand, Balzan et al.[147] by investigating cold chain and consumers' practices, reported that whilst the food safety knowledge appears fairly at a good level, the consumer practices were deemed not so appropriate

particularly with respect to the transport from store to home, as well as from storage to thaw. In addition, consumers were also particularly concerned that frozen food should not be thawed during transportation.

Hazards analysis and critical control points (HACCP): From fundamentals to categorisation

Introducing HACCP

As a QA-based platform, HACCP aims to meet up with customer expectations, appropriate product specifications, and food safety requirements. It flow-charts the production process, which necessitates HACCP plans consistent with Codex guidelines.[181] According to the Hygiene Rules 93/43/EEC for European food production and based on FAO/WHO Codex Alimentarius, HACCP globally asserts itself as systematic food safety assurance method used to identify, evaluate and control food safety risks.[47,150,156,182] The design of HACCP should be such to identify either the specific processes/steps and or the processing requirements that eliminate, prevent, or reduce an identified hazard to an appropriate/acceptable level.[183] Simplifying the HACCP system to a convenient level may facilitate its integration into the processing systems. As such, the traditional processors could therefore be incorporated using the rather simple techniques, for example, operation time, use of pH strips, and visual examination, so as to assure the product safety.[97] In addition, HACCP's monitoring and verification phases can include the conditions surrounding the thermal processing of canned foodstuffs and other kill steps such as cooking, baking, or sterilising.[183]

Guarantees of HACCP

HACCP guarantees food safety through the adherence of cost-effective preventive and systematic measures.[20] HACCP connects with epidemiological data from surveillance to risk assessment of foodborne disease [102] and most effective to guarantee consumer safety such that foodstuffs will neither be contaminated nor polluted within the supply chain.[33] Given the complexity of food recipes/menu, a flexible HACCP system would suit food operators/services better.[127] By drawing up hygiene codes of practice, applying HACCP principles help identify hygiene risks across food producers.[154] In UAE for instance, the government drives HACCP through four key elements, namely: a) government commitment and leadership; b) appropriate enforcement of legislation; c) food safety risks and strategies to encourage and facilitate the implementation of HACCP via training.-[176] Apart from the HACCP system assuring more structured surveillance over-determined hazards, the corrective actions require a multidisciplinary approach, involving the control of records, documentation, and personal responsibility. When non-conformities in the agro-food product industry are discovered, apart from enabling traceability, the HACCP system facilitates rapid response to changes and enables continuous checks to confirm efficiency.[68]

Developing a plan/team in a HACCP system

Certain criteria must be met within the HACCP system to ensure the adequacy of HACCP plan, [184] which would involve hazard analysis, determination of critical control points (CCPs), critical limit, monitoring procedures, corrective action, verification procedure and documentation.[149] The required stages/steps of developing a promising HACCP plan are presented in Table 3. Herein, HACCP principles can be seen as workable activities, that is, what is involved, what should be described, what should be developed/verified, as well as what should be conducted, determined and established. To produce a robust HACCP system requires assembling the HACCP team, description of the food, and its distribution as well as intended use and consumers, prior to its evaluation and revision.[183] The success of developing, installing, monitoring, and verifying a progressive HACCP

Table 3: The required stages/steps of developing a HACCP plan, modified from Benne and Steed.[183]

Steps	Remark(s) of each step
1. Assemble the HACCP team	It can include five, seven or probably more persons from different operational units of food industry.
2. Describe the food and its distribution	It can involve what is the intention of sale, and how it will be preserved.
3. Describe the intended use and consumers	What are the risks of abuse and misuse?
4. Develop a flow diagram of the HACCP activities/processes	The diagram should be schematic. It should also include (some) pertinent details about the process.
5. Verify the flow diagram	In the verification process, the activities should be consistent with adherence to prescribed (HACCP) contents/practice
6. Conduct a hazard analysis	Identify with the ingredients, packaging and processes
7. Determine the critical control points (CCPs)	Identify with the few food safety points
8. Establish the critical limits to CCPs	It must be science based and measurable
9. Establish the monitoring procedures	It must indicate who checks and how frequent the check has to be carried out
10. Establish corrective actions	It will include activities of how to fix, hold, notify and dispose
11. Establish verification procedures	It will include who conducts the checks and countersigns
12. Establish record keeping and documentation procedures	It will include all documents such as manuals and log books
13. Evaluate and revise the HACCP system	Checking through the various stages for consistency and coherency.

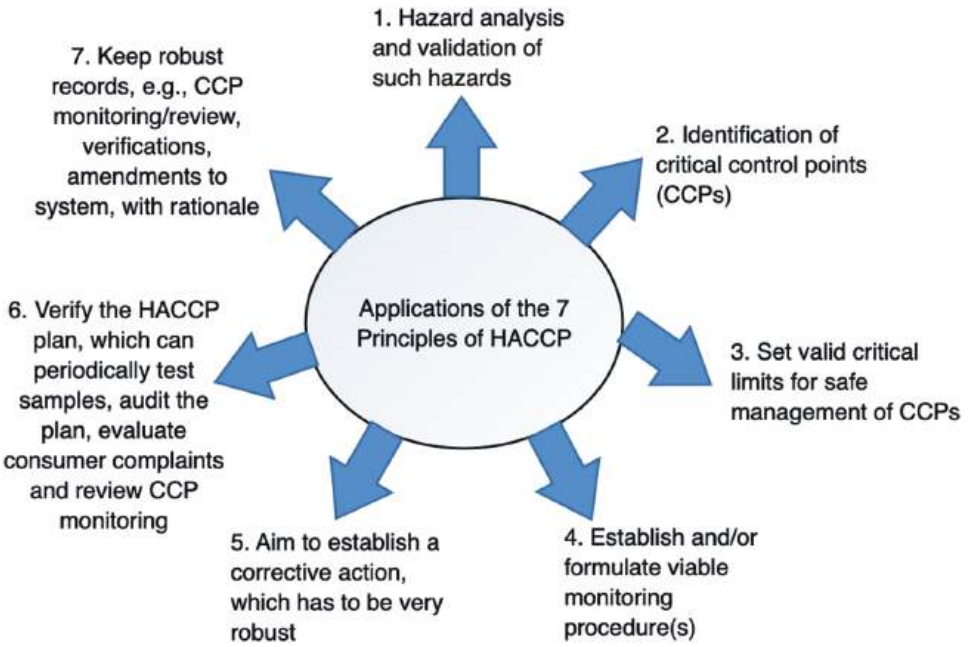

Figure 5. The seven (7) major applications of HACCP principles (Source: Aruoma [23] with slight modifications [permission from Elsevier Science])

system depends on how complex the interaction of managerial, organisational, and technical hurdles are likely to be. As large food establishments see HACCP challenges as difficult, the small and medium enterprises (SMEs) would definitely see it as potentially insurmountable.[185,186] Whilst developing a (HACCP) plan may take time, the emerging (HACCP) system may be in place for several decades.-[155] Indeed, the HACCP plan enhances the food industry's capacity to systematically design programs that implement the microbiological safety of foods.[187]

HACCP: From principles to implementation

The seven major applications of HACCP principles are shown in Fig. 5, which are seven in number, enumerated as follows: a) assessing/identifying threats and possible hazard occurrences and determining control measures as well as counteracting methods of threats; b) determining critical control points (CCPs) so as to minimise hazard occurrence; c) identifying with the established critical limits for CCPs; d) determining/implementing CCPs monitoring systems; e) establishing corrective actions if CCPs do not fulfil needed requirements; f) establishing verification procedures so to verify the effectiveness of the system, as well as if it works according to plan; and g) elaborating and maintaining HACCP system documentation, specific to determining/implementing method of data registration/storage as well as archiving of documentation system.[23,43] Clearly, the HACCP involves the procedures that guarantee the food safety of (food) establishments, by assessing the threat(s) from both health quality and food product viewpoints, added to the hazard risks that could potentially arise within the food production stages.[23] In addition, identifying CCPs refers to knowing the critical point between safety and insecurity, that is, food is considered safe only when critical points are controlled within a safe range. Hazard analysis evaluates CCPs, from point of purchase, loading, storing, transport, sorting, and processing, for example.[188]

HACCP assessment verifies if food distributor/manufacturer can respectively distribute or produce safe food products. Effective implementation of HACCP requires food manufacturers to implement verification procedures, systematic assessment of all food preparation/production stages, controlling as well as identifying with all pathways critical to (food) safety.[26] The competences as well as qualifications of workers remain among the challenges that confront the HACCP implementation process, especially within the food safety system. Some trainers that provide the HACCP training, do so without considering both depths (which areas/concepts and to what extent that needs to be taught), and scope (what had to be taught/what need not have been taught) of coverage. Some managers possess a limited understanding of the global food strategy, as should be required within the food industry. Given the high reliance on a certificate rather than on the competence, food operations should be seen to seek highly motivated food hygiene managers to develop, who would strive to maintain and sustain a robust food safety culture.[154] In addition, the effective implementation of HACCP can play a role in minimising food product recall, arising from contamination.[102] Nonetheless, HACCP in food safety management will become effective only if the personnel responsible for its implementation have the required knowledge and expertise.[23] Besides human resource management being essential to the HACCP system, [68] implementing the HACCP plan/systems would ensure food safety within the agro-food product industry actually works, especially through the (food) process control functions.[181] Given its(over) reliance on the qualitative aspect of the hazard (analysis) and its control mechanisms, the acceptance as well as the application of HACCP in a given food establishment has continually been confronted with limitations.[187] In addition, small food retail mostly encounters a wide range of challenges in HACCP implementation/plans.[189]

Previously conducted HACCP (implementation) studies

Summary of previous studies that investigated HACCP implementation across different agro-food products and related sectors with respective (HACCP) emphasis/focus is shown in Table 4. Sectors that were reported with HACCP implementation, include foodservice operation/industry, [195,208,210] ice cream factory, [199] local food industry, [97,196] food business/enterprise [185,192,200,203,204,212,213] and small and/or medium food enterprise/industry.[193,201,205,209] The processing industries/plants of meat, [191,194,202,206] fish, [197] poultry, [198] and dairy [211] sectors, as well as school foodservice [207] were also investigated. HACCP (implementation) focus includes its commitment to/level of/interpretation, [193,209,212] effectiveness, [97] procedures and practices, [207] difficulties and barriers, [185,201] adding its impact on food safety control process, [211] microbiological quality/outcomes, [191,196,199] as well as usefulness to foodservice operations.[210] Other HACCP focus included

Table 4 :Summary of previous studies that investigated HACCP implementation across different agro-food product and related sectors with respective (HACCP) emphasis/focus

References	agro-food product supply chain and related sector	HACCP implementation objective of study	HACCP emphasis/focus
Trafiałek and Kolanowski [190]	Food businesses in Poland	To examine the effectiveness of functioning of HACCP principles in certified and non-certified food businesses in Poland	HACCP impact on food business industry sector
Tomasevic, Kuzmanović, Anctelković, Saračević, et al [191]	Meat processing plants and retail facilities in Serbia	To determine the effects of mandatory HACCP implementation in meat processing and retail establishments in Serbia	Microbiological outcome of mat processing plant and retail facilities before and after HACCP implementation
Trafiałek, Lehrke, Lücke, Kołożyn-Krajewska, and Janssen [192]	Food enterprises at Germany and Poland	To study HACCP implementation at Germany and Polish food enterprises	HACCP implementation according to define 12 steps of Codex Alimentarius Commission
Dzwolak [193]	Small food industries in Poland	To show how small and /or less developed food businesses in Poland have implemented some elements of the HACCP system	How HACCP is interpreted in Poland and main solutions to help HACCP implementation in some small Polish food businesses
Baek, Kang, and Lee [194]	Meat processing plants in South Korea	To investigate the problem and benefits associated with HACCP implementation on livestock product plants in South Korea	Implementing HACCP on accredited meat processing plants
Shih and Wang [195]	Catering food operations in hospital	To investigate the potential factors that may influence implementation of HACCP systems in hospital catering operations in Taiwan	Satisfaction, difficulties, and benefits related to HACCP implementation
Kokkinakis, Kokkinaki, Kyriakidis, Markaki, et al. [196]	Local food industries in Crete, Greece	To survey microbial changes that followed in the HACCP implementation in local food industries in Crete, Greece	Changes in microbiological quality of locally produced/packaged food (ice cream, sandwich etc) after HACCP implementation
Lupin, Parin and Zugarramurdi [197]	Fish processing plants in some Latin American countries	To demonstrate techno-economic merits of applying HACCP with focus on quality cost methodology in fish processing plants in some Latin American countries	Quality costs before and after HACCP implementation, highlighting problems and resultant benefits
Kök [198]	Poultry industry in Turkey	To determine the extent of HACCP (and ISO 22000) implementation in the Turkish poultry industry	Impact of HACCP (and ISO 22000) implementation on poultry meat producers, comparing small-medium and large firms
Kokkinakis, Fragkiadakis, loakeimidi, Giankoulof, et al. [199]	Ice cream factory in Greece	To screen microbiological quality of ice cream and safety of production after HACCP implementation	HACCP impact on microbiological quality and product safety of ice cream
Semos and Kontogeorgos [200]	Food industry in Greece	To report the perceptions of costs and benefits of HACCP implementation for the food industry in Greece	Some aspects, e.g., benefits derived of HACCP implementation and operation in food industries
Baş, Yüksel, and Çavuşoğlu [185]	Range of food businesses in Turkey	To determine the barriers of HACCP (and food safety program) implementation in food businesses in Turkey	Barriers, challenges and difficulties encountered in HACCP implementation
Celaya, Zabala, Pérez, Medina, et al. [201]	Food industries in autonomous communities of Madrid, Spain	To evaluate the HACCP implementation in small food industries at autonomous communities of Madrid, Spain	Important barriers about HACCP implementation
Amoa-Awua et al. [97]	Semi-commercial kenkey production plant in Ghana	To apply HACCP (and GMP) to traditional food processing at a semi-commercial kenkey production plant in Ghana	To assess the effectiveness of HACCP (with GMP) by monitoring the environment and kenkey production, as well as auditing and verification of HACCP
Khatri and Collins [202]	Meat industry in Australia	To determine the impact of HACCP implementation of meat industry in Australia	Motivators, constraints, costs and benefits of HACCP implementation

(*Continued*)

Table 4 (Continued).

References	agro-food product supply chain and related sector	HACCP implementation objective of study	HACCP emphasis/focus
Bai, Ma, Yang, Zhao, et al. [203]	Food enterprises in China	To survey HACCP implementation across food enterprises in China	Key aspects, incentives and rewards of HACCP implementation
Baş, Ersun, and Kivanç [204]	Food businesses in Turkey	To determine food safety practices and procedures related to HACCP (and prerequisite programs) implementation in food businesses in Turkey	Knowledge base, food safety practices, and (prerequisite program) challenges encountered in HACCP implementation
Fielding, Ellis, Beveridge and Peters [205]	Small medium food manufacturing enterprises in UK	To evaluate HACCP implementation levels/status n across small and medium enterprises (SMEs) in UK food manufacturing sector	Levels of understanding of hazards and risks in SMEs within HACCP implementation
Maldonado, Henson, Caswell, Leos, et al. [206]	Meat industry of Mexico	To determine the levels of HACCP implementation, costs of implementation and operation, and benefits of implementation for the Mexican meat industry	Cost-benefit analysis and associated aspects of HACCP implementation
Youn and Sneed, [207]	School foodservice in Iowa, USA	To determine food safety procedures/ practices related to HACCP (and prerequisite program) implementation in school foodservice in Iowa, USA	HACCP implementation impact on food certification levels, food safety procedures, and employee responsibilities
Worsfold and Griffith [208]	Catering industry in Wales, UK	To evaluate caterers' perceptions of HACCP (and hygiene) in food businesses/services in Wales, UK	Caterers' perception of HACCP training; To design, deliver and evaluate HACCP training courses for caterers
Walker, Pritchard and Forsythe[209]	Small and medium sized food businesses in UK	To quantitatively assess HACCP (and prerequisite programme) implementation across small and medium sized food businesses in UK	HACCP implementation outcomes in terms of level of commitment, as well as time, temperature and cross contamination controls
Nam, Kim, and Lee [210]	Food service industry in Daegu, South Korea	To determine the effects of HACCP implementation on foodservice industry operation in Daegu, South Korea	Impact of HACCP implementation on some foodservice operations
Henson and Holt [211]	Dairy processing sector in the UK	To explore the incentives that motivate the adoption of food safety controls through HACCP implementation in UK dairy processing sector	Food safety control processes of HACCP implementation adoption in businesses/firms
Panisello, Quantick and Knowles [212]	Food industry in Yorkshire and Humberside regions of UK	To survey HACCP implementation of food industry in Yorkshire and Humberside regions of UK	To establish parameters that affect/ influence HACCP implementation, information about industry's hazard awareness as well as barriers to (HACCP) implementation
Ehiri, Morris and McEwen [213]	Food business operators in Glasgow, UK	To survey the HACCP implementation, whether the information is reaching its target, among food business/ operators specifically in Glasgow, UK	Knowledge of, attitudes to and opinions about HACCP strategy (as introduced into Food Safety (General Food Hygiene) Regulation of 1995)

understanding hazards and risks, [205] quality costs before and after its implementation, [197] caterer's perception during its implementation/training, [208] establishing motivators/satisfaction, difficulties/constraints, costs/benefits during its implementation, [195,202,206] as well as its overall outcome[190,192,194,198].

Youn and Sneed [207] reported the HACCP implementation rate of 22% in foodservice in schools at Iowa schools, which had about two-thirds of directors with a food safety certificate. Having an employee primarily responsible for food safety could increase the chances of HACCP implementation. Shih and Wang [195] reported differences in age, gender, and job position as factors that could influence HACCP implementation in the catering unit of Taiwanese hospitals. The catering staff largely agreed that HACCP would improve the hospital's catering. Worsfold and Griffith [208] indicated that whilst the performance/reaction of caterers on the HACCP free training course was

good, the understanding of hazard risks and risk management was low. Indeed, the short-/long-term evaluation may help in widening the HACCP strategy. Elsewhere, the HACCP manual, description of catering service, hazard analysis worksheet, process packs, as well as instructions and procedures were among practical approaches considered useful to facilitate HACCP implementation.[193]

Amoa-Awua et al. [97] investigated the HACCP implementation at semi-commercial kenkey production plants in Ghana, which studied how hazards, aflatoxins, and enteric pathogens associated with the fermented maize product (kenkey) were managed. Results showed raw materials, products, and processing parameters conformed to the critical limits that ensured food product safety. In addition to the reduced aflatoxin levels, such bacterial pathogens as *Escherichia coli, Staphylococcus aureus, Enterococcus* spp., *Salmonella* spp., *Bacillus cereus*, and *Vibrio cholera* were not detected in any of the finished products. Investigating food business operators in Glasgow, Ehiri, Morris, and McEwen [213] reported about slightly over half (59%) had not heard about HACCP. In that study, slightly over half (67%) indicated they needed assistance to identify hazards, CCPs, and monitoring procedures in the food processes. Across the UK food businesses, Walker, Pritchard, and Forsythe [209] identified temperature control activity as least likely implemented because 60% of them (food businesses) employed domestic refrigerators for common purposes, with only about 40% that used temperature probes. Further, about 65% kept records like temperature logs and delivery notes with no apparent reason. A food industry survey by Panisello, Quantick, and Knowles [212] showed the majority of food companies implemented HACCP although lack of knowledge/expertise, as well as the adequacy of resources, still persisted as challenges. Celaya et al. [201] revealed that whilst food industries would have the capacity to apply strategic plans for HACCP implementation, the small (food industries) ones still have several challenges/hurdles in this regard. Additionally, Baş, Yüskel, and Çavuşoğlu [185] identified the lack of prerequisite food safety programs as a key barrier, followed by the lack of HACCP knowledge that retarded the food safety in (food) businesses in Turkey. Elsewhere, Baş, Ersun, and Kivanç [204] reported that within HACCP – implemented food businesses, proper food safety practices and prerequisite food safety programs were oftentimes not adhered to, attributable to the low level of food hygiene management training, lack of motivation, equipment/facility inadequacies and failure of government (support). Maldonado et al. [206] reported that investment in equipment and microbiological tests of products accounted for most HACCP implementation operational costs. Whilst microbial count reduction remained a major benefit, HACCP implementation had implications for both domestic and international food markets.

Trafiałek et al. [192] considered the HACCP implementation in Poland to comply somewhat amicably with the Codex Alimentarius principles and Regulation (EC) No. 852/2004. Further, Trafiałek and Kolanowski [190] understood that the overall assessment of HACCP principles would appear higher in certified food businesses compared to non-certified ones. Despite the certification and food industry type(s), assessing the HACCP principles' functioning across business groups could appear less. In a similar context, Kokkinakis et al.[196] reported the HACCP system would produce a positive effect on the microbiological quality of emergent/resultant products, even though the systematic differences in the HACCP adoption process between the individual firms still persist. However, it is important to reiterate that the decision to adopt HACCP may actually be dependent on the characteristics of firms, for example, firm size and type of products manufactured.[211] In China for instance, medium-to-large size food enterprises are believed to dominate in the HACCP implementation process, which might actually be responsible for their capacity to produce internationally marketed food products. Further, the improved quality of the food product, the capacity to gain access to the new markets, and increased capacity of the market share still remain among the top incentives that drive China's HACCP implementation processes.[203]

The combination of HACCP and ISO 22000 appears to be receiving increasing attention. This is what Kök [198] observed as large poultry firms in Turkey had employed more stringent schemes, making better use of government services compared to the small-medium counterparts. HACCP implementation, according to Baek, Kang, and Lee, [194] aims to improve hygiene in meat processing

plants, customer satisfaction, processing plant image, and (plant workers) understanding of food hygiene. It can, according to Tomasevic et al., [191] provide a strong positive effect on the hygiene production process for a given meat processing establishment. In this context, the pathogenic bacteria like *Enterobacteriaceae* and *Staphylococcus* would be the least of the challenges that would affect the meat handlers. It can also, according to Lupin, Parin, and Zugarramurdi, [197] reduce failure costs, improve (production) quality, and better the knowledge of production control as well as planning in a given fish processing plant. Moreover, HACCP implementation in the meat industry particularly across Australia has been more widespread and significant, reducing customer complaints and improving the hygiene of meat products.[202] Whilst the benefits would include the improvements in the food product and production procedures, Semos and Kontogergos [200] identified staff training and production flexibility as major challenges encountered during HACCP implementation in the food industry in Greece. Fielding et al. [205] reported that a majority of workers SMEs in UK food manufacturing operated hazard analysis-based QM, some still found it challenging to correctly define the hazard or risk, or identify the different hazard types. Other workers like Nam, Kim, and Lee [210] understood that at the post-HACCP implementation stages in a foodservice operation in South Korea, the heated foods brought about increased changes in the microbiological quality, indicative of improved standard levels after cooking and serving stages. However, it was understood that the HACCP implementation may not always influence the microbiological quality/level of foods prepared after heating, compared to the non-heated ones.

Categorising/defining the CCPs in HACCP

Regarding the hazards and preventive measures, categorising CCPs would depend on processing plant stages/steps especially with reference to the production/processing of fresh and frozen food products.[156] This is because, the program protocol that is fundamental to the HACCP, would involve: a) identification of food safety hazards; b) identification of processing approaches that best control hazards; and c) implementation of control plan. It is this control plan, which when implemented, would involve several steps designed to eliminate and or minimise hazard, to eventually bring about CCP levels. For example, if a CCP can control hazards completely, it is designated as CCP-1. If it can control minimise hazards, it is designated as the CCP-2.[156] In addition, HACCP analysis should also identify CCPs associated with packaging, which can involve chemical, microbiological, and structural specifications of packaging materials.[32] In the food plant process system, the HACCP analysis should utilise a flow chart/diagram to point out the CCPs (within the process), the latter to depict the stage(s) where the failure to control would allow for the development of microbiological hazards. Thus, each CCP could help indicate some potential control over the hazard that is being identified.[32] By considering the HACCP principles particularly through the evaluation of microbiological safety, it can then be possible to define the adequacy of the CCPs. This should be conducted at the earliest time, especially when the processing system identifies with the corresponding (agro-food) product.[32] In such scenario, the CCP evaluation would involve raw material and ingredient handling, adequacy of time/temperature and sanitation requirements, prevention of cross-contamination, food handling, and employee hygiene, etc. Such evaluation should also relay the items, potential hazard(s), proper controls/procedures and monitoring systems to be employed at each critical point, as well as the individual/staff accountable for the item.[32]

CCPs can also be identified in the risk assessment of food processing plants, which HACCP plan would help to implement. In fact, the ISO 22000 analysis work sheet can help in determining prerequisite programs (PRPs), which help to differentiate the ISO 22000 and the HACCP. The PRPs therefore, when incorporated, can make the ISO 22000 to become more flexible.[214] For instance, the Polish Law defines the HACCP system as the activities that ensure food safety through the assessment/identification of hazard scale from the viewpoints of health and hazard risks during all food manufacturing/trade phases.[101] In agreement with the Codex Alimentarius documents, the HACCP

system (under the Polish law) covers the following actions/procedures: a) identification and assessment of health dangers of food quality and occurrence risks as well as the establishment of control/counteracting means/methods of (such) dangers; b) specifying critical control points (CCPs) that help eliminate/minimise such dangers; c) establishing parameters/requirements for each CCP that needs to be fulfilled and specifying the tolerance range (critical limits); d) developing/implementing monitoring system of the CCPs; e) specifying the corrective actions especially if the CCPs do not meet the (above-mentioned) requirements/parameters; f) developing the verification procedures that conform the compliance and efficiency of the HACCP system; and g) developing the HACCP system documentation, that is related to the implementation phases, and specifying the system of data registration, storage and filling of system documentation.[101]

Quality assurance (QA) and control systems: Some essentials

QA plays a significant role in the food sector by guaranteeing that all quality obligations like food reliability and safety are met. By establishing the processes and procedures, responsibilities, as well as standard organisational structure, several QA systems, successfully targeted the food industry needs through the HACCP, International Standard Organization (ISO), etc.[20] QA standards procedures must be developed at every stage and documented with detailed protocols that address both operations and processes. In addition, protocols need to be accurately and clearly organised, with the corresponding date and signature of the person that has prepared them.[31] Decades earlier, cleanliness of food unit facilities like packaging, processing, and production were considered in hygiene control/sanitation – an integral part of quality control.[164]

Within the food industry, the QA integrates with food safety to develop a quality safety management system.[215] Quality program in the (agro)food industry should integrate quality/safety requirements of food with a set of clear (and well thought through) objectives that consider the required specific raw materials, production, as well as structure of enterprise.[82,216] By adopting the QA systems, the competitiveness in the market would improve. This, however, may not appear so for the small food enterprises, even in the EU.[38] By adopting multiple-hurdle approaches, which would involve training food handlers to be effective in the postharvest hygiene and implementation, the meat industry not only to control the foodborne pathogens of beef, but also, can help to consolidate the QA procedures/framework.[156] When employed in a given agro-food establishment/unit, the QA systems should permit both application and verification of control measures, which assures the quality and safety of the food product. At each step within the food production line, the QA ensures that safe food adheres to both customer and regulatory requirements.[82] Therefore, in order to secure the most appropriate QA system, governments have a vital role to play, especially to provide policy guidance towards the implementation of the QA.[40]

Quality control involves inspecting, testing, and monitoring associated with the control of raw materials, process and finished products. It further aims to fulfil quality outcomes as well as specifically detect if unacceptable defects/hazards do actually exist in the foods.[38] However, the QA in the agro-food product industry would involve a more extensive scope compared with quality control. Beyond inspection, testing, and monitoring activities, QA would involve additional activities devoted to preventing food safety hazards and quality defects.[82] Further, QA control points (QACP) is among (quality) systems strictly based on the HACCP concept within food production. Whereas HACCP is focused on food safety, QACP is focused on the QA system. Although unique for each food establishment, both HACCP and QACP have to be effectively and robustly introduced *as per* the (respective) processing/production line(s).[47] GMP alone cannot serve as the basis of the QM system, given its standardised guidelines for the safe production of foodstuffs. However, GMP should be very effective if the HACCP team considers (its) control measures.[51]

The assurance of food quality and safety guarantees that the agreed-upon specifications of food products have to be met, and is safe from causing harm.[217] Besides, food safety in the QA domain is considered as obligatory, but not so for QM, given the relationship between food legislation, safety, and

quality systems, official inspections, and customer requirements.[47] Similarly, the food manufacturers consider food safety as a prerequisite especially when QA measures are incorporated. Importantly, QA, when applied, would protect the domestic food industry against international competitors.[218] Moreover, the (food) industry-based QM system have involved both food quality and safety standards, usually established for a wide range of (agro)food products.[91] In the UK for example, the BRC defines the common criteria that covers the inspection of food suppliers, usually in coordination with major food retailers. Previously, the food retailer(s) would conduct individual inspections but soon enough realised/understood the cost-effectiveness of joint operations.[26] Indeed, the HACCP requirements can be part of BRC, which provides it considerable emphasis on documentation, personnel as well as process/product control.[26] In addition, the framework of BRC largely ensures that the manufacturers produce safe food products and that at the same time manage quality. In addition, the broad scope of BRC strengthens the connection between consumers and retailers.[26]

Other quality standards associated with agro-food product industry

The ISO quality standards used in agro-food industry

a) Comparing between ISO 9000 and 22,000 quality standards

Focused on quality health/safety, the key objective of ISO is to promote the standardisation of the given production process. Applying the ISO system to a food unit increases the insight(s) about both effectiveness and efficiency, not only in cost savings but also in both customer satisfaction and maintaining improvements.[20,26,183] The ISO 9000 family of quality standards, among the most widely known of the ISO standards, constitutes a variety of QM facets. By guiding and supporting both companies and organisations, the ISO 9000 quality standards utilised can provide tools that are required to ensure the products/services are consistent with the customers' needs, for the continued improvement of the overall organisational quality.[26] With QM as the focus, the ISO 9000 quality standards would apply to the different establishments regardless of branch, product, or service. The ISO 9000 quality system series constitutes the following quality standards: a) ISO 9000 – the basis of QM terminologies and systems; b) ISO 9001 – specifies requirements concerning QM systems; c) ISO 9004 – specifies guidelines for improving an already implemented QM system.[43] In addition, the ISO 9001 encourages the effective use of raw materials, equipment, and resources.[219]

Specifically, ISO 9000 appears to be the more widely used quality standard, which would be applicable to the agro-food establishment/industry). It is based on the following eight principles: a) continuous improvement; b) customer-oriented; c) decision-taking based on facts; d) leadership; e) mutually beneficial cooperation with suppliers; f) personnel involvement; g) process approach; and h) system approach to management.[43] Whilst ISO9000 quality system series is voluntary and comes at a cost to the establishment that embraces it, the greater benefit is the increased concentration/understanding it provides on the quality system.Conceptually, the ISO 9001, for example, would present a cyclic connection, that is, management leadership involvement>process management and control>-process system improvement>quality system support>management leadership involvement.[183] As a system, the QA provides some confidence to the food company's management, as well as the government/national regulatory agencies. Through this, the said (food) company could develop increased capacity to attain the designated (food) quality/safety requirements. For example, ISO 9001: 1994 QA system standard got replaced by ISO9001:2000 QA system standard. Notably, the companies to operate with the QA system should have the prerequisite QA activities incorporated within the QM systems.[82] Notably, the International Featured Standards (IFS) corroborates the ISO9001 but has ample focus on the food safety, HACCP, hygiene, and manufacturing processes, which would be very relevant for today's food industry.[20]

Comparatively, the ISO 22000 standard is more recent than the ISO 9000. Specifically, the ISO 22000 standard unifies the principles of quality systems employed in the (agro)food industry.[43] ISO 22000 standard equally facilitates the (food) establishment's capacity to adopt a food chain approach,

so as to develop, implement and improve the effectiveness as well as efficiency of (food) safety management.[26,220,221] Further and in diverse ways, the ISO 22000 as a management standard strengthens not only the HACCP but also the preventive action procedure(s). Whereas the HACCP (which is a requirement of ISO 22000) is designed to prevent food safety hazards, the ISO 22000 standard recognises that as new hazards emerge, new control systems/technologies should be designed to control them. In addition, hazard assessment in ISO 22000 standard helps in determining potential hazards that require specific control measures. Besides, the ISO 22000 can be implemented when combined with ISO9001 and its supporting standards.[26,220,221] Nonetheless, the ISO 22000 standard remains firm and robust among the Food Assurance Systems (FAS) with a vertical feed to retail as well as global geographical scope, serving the public interest. With consumer participation as key, the ISO 22000 appears as a de-centralised management system largely driven through the supply chain partnership.[91] An example of ISO 22000 standard is the ISO 22000:2005, which has been associated with how the food establishments should control the food safety hazards with a robust competitive advantage.[26,222] Although optional and beyond the framework of GHP/GMP/HACCP requirements, the ISO 22000 range/scope essentially covers the following: (a) range of such prerequisite programs as GHP, GMP, GAP, GVP (Good Veterinarian Practice), Good Kitchen Practice (GKP), GCP, GPP (Good Production Practice), GDP (Good Distribution Practice) and GTP (Good Trading Practice); (b) HACCP system; (c) Identification/Traceability system; as well as (d) QM system ISO 9001. Clearly, the design of ISO 22000 and by integrating both HACCP and QM, allows for an effective food quality/safety system, which if implemented can bring about increases in product quality gains/profits.[43,47]

b) Acquisition and status of ISO 9001 and 22000 certificates/certification in agro-food sector

In recent decades, the ISO 9001 certification has occupied useful space within the agro-food industry/sector. The process to achieve either ISO9001 or 22000 certification is well known to be extremely tedious as well as rigorous. That alone scares off many low capital/small-scale aspects of the agro-food sector. A schematic flow showing some basic auditing stages to attain ISO9001/22000 certification, from intention to apply, through the audit processes, to issuance of certificate/certification is shown in Fig. 6. From this, we can see that the agro-food sector has to think very hard as to whether obtain, for example, the ISO9001 certification. The intention to acquire quality certification like ISO 9001 should not be for the sake of "obtaining a certificate" and the expectation to acquire greater benefits,[26] but should be more on consolidating quality improvement and consumer confidence to the quality of agro-food functions, products, services, and processes. Remember that ISO 9001 operates at a global/international level. How the auditing process is carried out should not differ much for ISO9001 certification to be obtained in Brazil or Taiwan. The same basic process shown in Fig. 6 should still apply regardless of country, it is still the same ISO9001 certification. Conde et al. [223] noted that ISO certification could positively influence companies' level of internationalization, and these workers could ascertain this when they investigated Spanish agri-food companies. The general consensus of these workers was that internationalization remained a key success factor in the competitive business environment that surrounds the agro-food industry/sector. According to Feng et al., [224] the effects of ISO 9001:2000 quality system certification could have on the operational and business performance of (agro-food) manufacturing and service organizations must not be underestimated. It has been shown that such effects could be positive and significant, especially the use of certification practices (the implementation process, organizational commitment, and subsequent planning) that relates to the operational performance.

Similar to ISO 9001:2015 that leads the globe in QM standards to assure consistency in product quality improvement, regardless of the field of activity, and size of the company, [225] the ISO 22000, management system is also among the favored certifications of the agro-food industry. At the international level, ISO 22000 helps to unify the standards between food chains across different countries, and this is through the issuance of certificates. For example, as of 2014 more than 30,000 ISO certificates are believed to have been issued worldwide.[226] By 2019, based on the ISO survey that showed evidence as per country and number of sectors, the evidence shows slight differences between

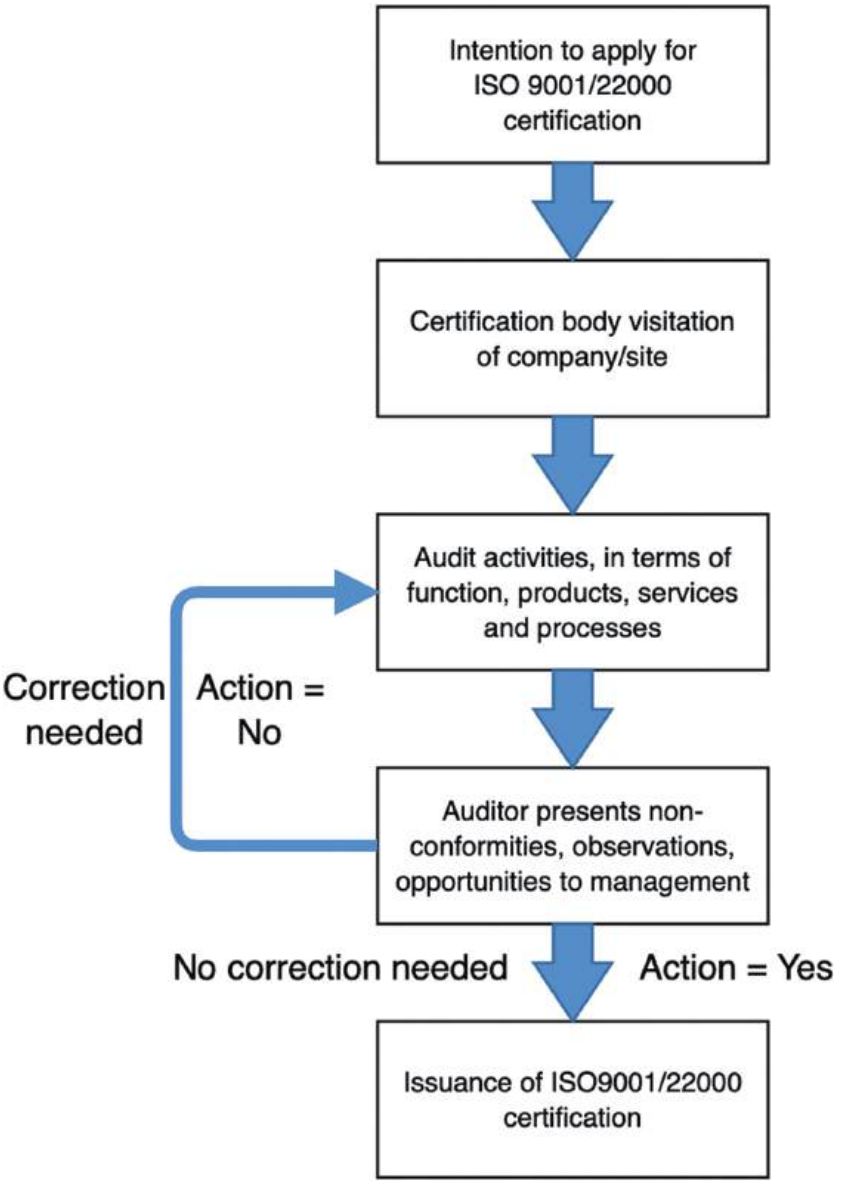

Figure 6. A schematic flow showing some basic auditing stages to attain ISO9001/22000 certification, from intention to apply, through the audit processes, to issuance of certificate/certification.

the number of certificates and sites. For instance, in some countries, the number of ISO certificates is slightly more than the sites, and vice versa. Considering both ISO9001 and ISO22000, China respectively leads with total number of 280,386/281,713 certificates and 12,144/12,426 sites. Globally, the total number of ISO9001 certificates and sites show 883,521 and 1,217,972, respectively. Globally also, the total number of ISO 22000 certificates and sites shows 33,502 and 39,651, respectively.[227]

Nonetheless, the process to acquire either ISO9001 or ISO22000 certification should not differ. Weyandt et al. [228] understood that the implementation strategies for ISO9001 and or ISO22000 certification in companies could be carried out either of these three ways, that is, separately, simultaneously or combined, that is, separately (1 standard), and simultaneously (2 standards). These workers also established that the required time to implement one or more of ISO9001/ ISO22000 certification

could range between 15– 32 months. These workers were also able to establish the critical factors underscoring the implementation of the ISO9001/ ISO22000 certification, which can include: a) The empowerment and valuing of people; b) Industry sensitivity towards the implantation of the management system; and c) Interpretation of the (quality-oriented management) standards. Notably, Escanciano and Santos-Vijande [229] identified some reasons for implementing and certifying ISO 22000, which included: a) Improving efficiency, internal processes/procedures, productivity and product quality and safety; b) Anticipating future market trends, strengthening the firm's competitive advantage, and improving the firm's image in the market; c) Customer demands and pressure, increasing market share, and gaining access to foreign markets; d) Complementing HACCP and other management systems, as well as reduce the need for customer audits. These workers also identified constraints confronting the implementation and certification of ISO 22000, which included: a) Not a prerequisite for doing business; b) Unfamiliar to consumers and customers, and of high cost; c) Not required by the government or public agencies; d) The need to hire specialized personnel; e) Paucity of information; f) Insufficient financial aid; g) Seems only interesting for exporters; and h) May not guarantee the total safety of the final product.

Halal and kosher quality safety standards within agro-food product industry

a) Halal quality safety standards

Globally, the Islamic consumers, in particular, comply with the halal criteria/standards and this phenomenon appears to be on the rise, considering the rapidly increasing food market.[230] Halal laws define food products either 'permitted' as halal, 'prohibited' as 'haram' or detestable/questionable as 'makrooh'. The law deals with the following five issues, all but the first associate with the animal kingdom: a) prohibition of intoxicants, that is, all that intoxicates, e.g., alcohol drinks; b) prohibited animals, e.g., pigs, boars, and swine, as well as some seafood, e.g., amphibians; c) prohibition of blood; d) method of blessing/slaughtering; as well as, e) prohibition of carrion.[231] Halal has specific peculiarities with cooking, food processing, and sanitation. Despite that alcohol is prohibited, there seem to be no restrictions on cooking. All halal and haram materials must be separated with respect to facilities, food preparation, etc. Non-halal facilities must be cleaned using halal prescribed methods.[231]

Halal requirements entail both criteria and legislation perspectives, where the food product must comply with: a) not containing elements not allowed by Islamic law; b) not in contact with (Islamic) prohibited substances during production, transportation, and storage; c) neither stored in facilities/premises nor transported using vehicles that are not permitted. Across all foods, it is the meat that is most strictly regulated in Islam.[230,232] From the EU legislative standpoint, however, no national (public) law stipulates a product has to be halal. However, the CAC has provided the general guidelines for halal food products with some room for minor differences in opinion. Whilst the halal legislation for animal slaughter would vary among countries, the labelling protects (halal) trademarks, to prevent producers from using the (halal) logo for non-halal products.[230]

Halal food supply chain, its integrity from farm to fork, can be seen in Fig. 7. Clearly, the process can be seen to involve the permitted foods and materials, ingredients, and processing, as well as packaging materials from agricultural inputs to consumers' stages. The range covered by both traceability and tracking of the halal status can also be seen.[233] In addition, the halal standards facilitate the certification process and customers' choice that complies with the food products. From the global standpoint, there are a number of halal organisations. For example, the World Halal Council (established in Thailand) that oversee over 40 halal certifications from different countries.[230] To meet the current demands of the (food) industry/sector, the Global Halal Management System (GHMS) attends to the food products, as well as its processes, with an increasingly detailed/robust framework/system that covers five facets, namely: a) Halal Fundamental Requirements; b) Quality Management System; c) Food Safety Assurance Plans; d) Corporate Social Responsibility; and e) Environmental

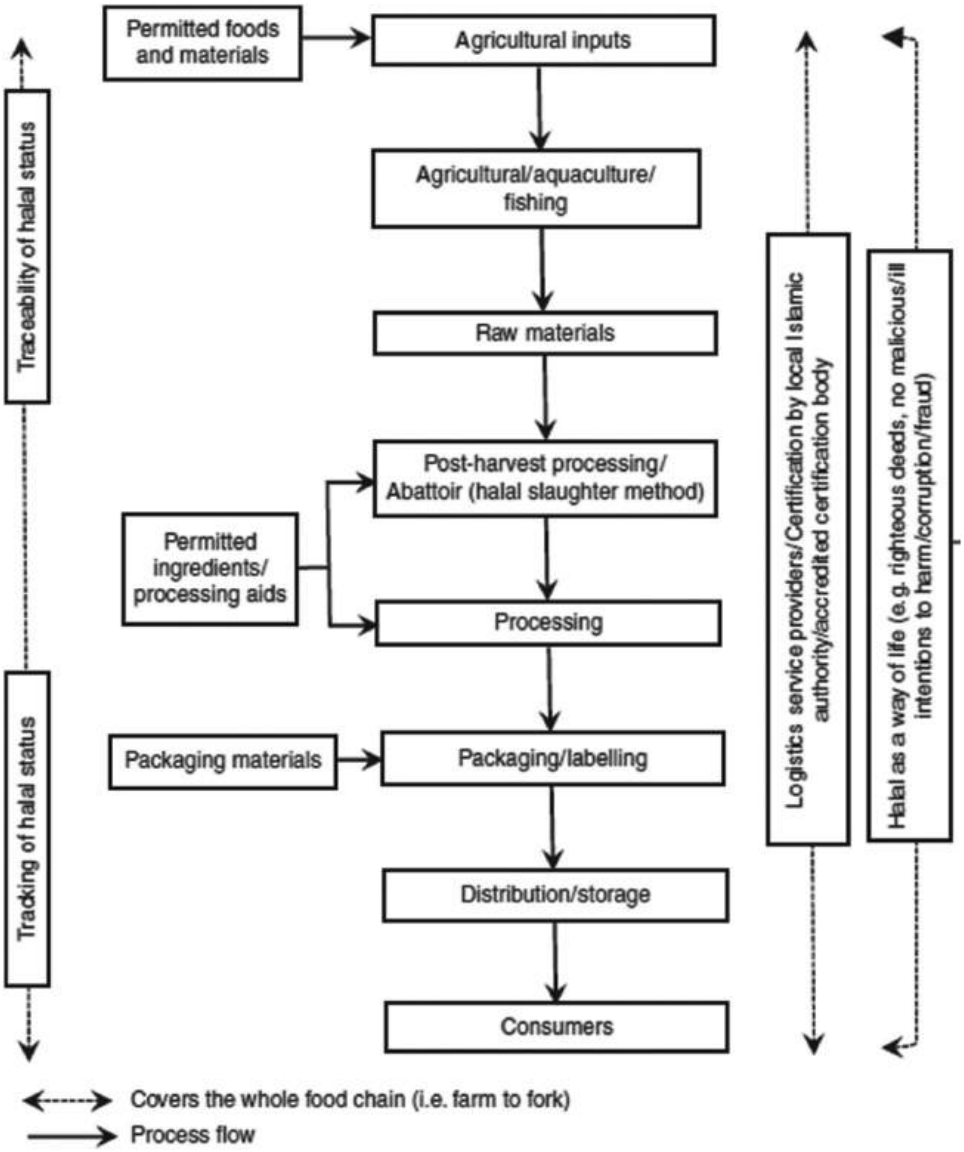

Figure 7. Halal food supply chain, its integrity from farm to fork (Source: Soon, Chandia & Regenstein [233] with permission from Emerald Insight Press)

Management and Sustainability van der Spiegel et al..[230] Gaining more grounds for example in Europe, there is the Muslim Food Board and Halal Food Authority both in the UK, as well as the Halal Food Council of Europe in Belgium.[230] Considering that food supply appears more often than not, no longer produced locally, halal continues to grow, and recent times becoming a global mega-trend food supply platform, even in developing countries.[92]

b) Kosher quality safety standards

Particularly among the Jewish communities, the Kosher dietary laws define the foods as 'fit' or 'proper' for consumption. This principle applies to a wide range of marketed food products. Predominantly, its certification deals with three issues about animal foods, which include: a) distinction between allowed and forbidden animals; b) prohibition of blood consumption; and c) prohibition of mixing 'meaty'

'dairy' and 'neutral' food.[231,234] What makes the food equipment 'Kosher' depends largely on the prior production history. For instance, within the Kosher-focused food industry, dealing with the day-to-day Kosher activities continues to pose challenges, given the diverse nature of (Kosher) supervision agencies, which constitute three broad/major categories, namely:(a) large organisations that dominate supervision of larger food companies; (b) individual rabbis, generally associated with 'Hassidic' communities often with special food brands; and (c) individual rabbis who are more 'lenient' than mainstream standard, able to cut out some of the stricter market standards.[235]

The Kosher food law and its certification have a primary focus, which has always been on both consumer protection and product compliance. It is based on this fundamental principle that the consumers' reliance and trust are invited on the Kosher (food law) and its (designated) product. In 1881, the first Kosher food law was enacted and this was in New York-USA. This 1881 law was legislatively amended in 1922 to make it a more comprehensive law. This New York Kosher food law/statute appears to be the model for all the subsequent food legislation. The enforcement of the Kosher food legislation has varied largely owed to variances in (Kosher's) interpretation.[236,237] The kosher certification of food products is granted by competent individuals or organisations. Importantly, it is the power vested on this competent individuals/organisations that provide the juridical/legal basis to determine that the product enjoys the kosher status.[236] In line with this, as the Kosher certification largely presupposes the inspection of item production serves as a verification of its (Kosher) status, wherein the standards guide the restrictions on the raw materials, production, as well as packaging. Among others, the (certification) process is by choice of the Kosher certification agencies, labelling product system, application of corporate information/manufacturing location, initial inspection, review of ingredients as well as (main) inspection/certification.[236] Besides, Kosher consumers have developed a trademarked labelling system on the food packages to identify the responsible party for providing (Kosher) certification.[92] In addition, Kosher prescribes a wide range of specific requirements for certain food products such as grape products, cheese products, milk products, as well as grain products. Observant Jews apply specific food standards to early fruits and Passover.[231,235] Similarly at the Passover, they avoid eating the usual products made from five prohibited grains, namely wheat, rye, oats, barley, and spelled. In addition, there are periodic recalls of specific products owed to the various kosher defects that would prevent its use, which continually justifies the making of Kosher of any food product as a legal claim 1 at the US Code of Federal Regulations.[231,235]

Factors influencing implementing quality assurance within the food industry/sector

A number of quality assurance schemes/systems abound within the global food industry/sector. The ability of any given food enterprise to adopt a quality assurance scheme/system in order to improve their competitiveness and productivity within its national or even global market remains dependent on a number of factors, which will be enumerated below:

a) *Cost to achieve quality*: Indeed, quality assurance comes at a cost, hence, the concept of 'cost of quality'. According to Bendell et al., [238] cost of quality provides unifying approach to drive quality improvement, and offers basis to identify and prioritise projects in such a manner that it is understood by all. Westgard and Barry [239] illustrated the cost of quality in terms of costs of conformance and costs of nonconformance to customer requirements, depicted in Fig. 8. Both Bendell et al [238] and Westgard and Barry [239] agree that quality costs entail appraisal, prevention, internal and external failure costs. In reality, quality costs require that the given organization's ability to identify the opportunities that need to be prioritised, and subsequently actioned. Small companies find it hard to implement QAS compared to the large ones, largely due to their small size and limited resources.[38,241,242] Moreover, the costs required to either introduce or systematize QAS can be very diverse.[38] For instance, the degree of the bottlenecks that small companies would encounter at adopting as well as implementing a QAS reflects on the cost per worker of implementingfor example, ISO 9000/ISO22000, multiplied by five when its size decreases by a factor of ten.[38,53]

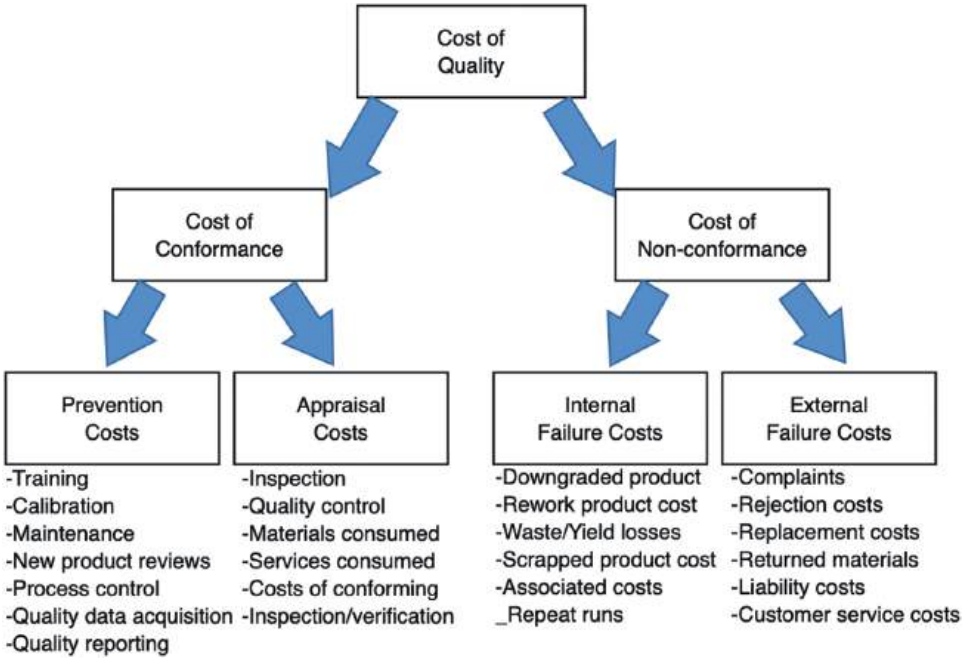

Figure 8. A schematic flow of cost of quality in terms of costs of conformance and costs of nonconformance in meeting up to customer requirements (Sources: Early [240]; Westgard & Barry [239])

b) Lack of quality manager, appropriate personnel and quality unit: Implementing quality assurance requires having the personnel that is fortified with skills to manage and lead the quality unit. Indeed, small enterprises could lack the appropriate/qualified personnel that is needed to implement such a system.[38] To see how lack of quality manager can make impact, we reiterate from Fig. 8, to see again the components of appraisal, prevention, internal and external failure costs, and its associated quality concerns, in order to reflect on how it eventually cuts across starting from calibration, acquisition, inspection, repeat runs, returned materials, to customer service costs. Certainly, if there is no quality manager, the cost to achieve a higher and a very market competitive quality product will go up substantially. According to Karipidis et al.,[38] when professional quality manager is absent in a small enterprise, it creates the need to hire an external consultant. How will the small enterprise know the right external consultant to hire? Moreover, the small enterprise may not even have the (internal) business credentials and skills to ascertain, evaluate, and eventually select the appropriate (external) consultants.

c) Lack of appropriate quality documentation/record-keeping: For quality to thrive in any given food company/industry, the QMS documentation has to be adequate and sufficient. Early [240] identified that there must be a quality manual that comprise job descriptions, procedures and work instructions. The training documents could also be part of the work instructions, and all put together form the quality records. Further to this, when there is paucity of record-keeping, it becomes difficult to know what records need to be kept, what they should look like, how they should be authorised/coded, how long they should be kept, as well as which ones should be disposed off and when. Document control is very core in QMS, and there should be a register for this within the company. Besides, some other workers[38,53,243] have opined that the importance of documentation appears not well understood, even by those who lead small enterprises. Besides, the large nature and volume of documentation that QMS requires could also be daunting, and discouraging, [38,240,244]

d) Lack of financial resources, which impedes human/personnel acquisition: Financial and human resources work hand-in-hand. The more the financial resources, the more the capacity to elevate the human and personnel resources.[38,238,240]

e) *Lack of quality culture, team and leadership*: The objectives of quality is achievable only through the creating the right-quality culture, as well as quality leadership. According to Early, [240] culture for quality improvement can be actualised through commitment and leadership from the management. The main source of commitment and leadership has to come from the chief executive, who must have the vision of quality and responsible to initiate the quality culture and improvement. Adair [245] proposed a team model for action-centered leadership, which involves an interaction of task, team and individual. Belbin [246] identified that, when building teams, the selection of team leaders is vital to ensure team dynamics produces higher probability of success.

f) Causes of discouragement: There are a number of causes of discouragement that have been considered relevant, which could influence the implementation of QA system in the food industry/sector as identified by several workers.[38,241,247–251] These causes of discouragement could be included as external or internal barriers. They include: (i) employees/managers having difficulties to commit themselves and their time to the task at hand. It is important that managers are equipped with the dedication and knowledge required. This will enable them tackle important quality-oriented problems, which would help to drive the improvement process forward; (ii) Inspectors may not have the required/sufficient knowledge; (iii) The inspectors may not be reliable especially if there are commercially oriented, which might make their auditing process questionable; (iv) The available ISO standards tends not to be flexible, and often considered too complicated to understand; (v) The unavailability of the appropriate educational programs/training; (vi) The unavailability of related/relevant reference quality manuals/materials. Sometimes, executives of small enterprises, in the process of adopting and implementing ISO 9000 systems, discover that, after the certification is achieved, another non-certified enterprise gets awarded a contract by client who had required them to be certified.[38,252]

g) Lack of choices, and investments: To assembly quality assurance system in the food industry is a decision, and requires making choice and being ready to invest in it. Especially for small enterprises, these two components could serve as barriers for progressing to achieving total kind of QM. A number of workers [38,253,254] have considered these (that is, decision as well as choice making) in the following: (i) To achieve quality improvement requires a certain degree of efficiency; (ii) Small food enterprises/industries are more likely to face limitations in quality programs requisitions; (iii) The process of making quality decisions as well as relevant choices demands the use of appropriate methodological tools.

h) Nature/type of goods/food product: The nature/type of goods/food product that the (food/food-related) enterprise trades in or produces could pose a wide range of obstacles to implementing quality assurance within the food industry/sector. For instance, we consider a delicate food product. When the quality system gets implemented, there is a higher chance that the number of nonconformities and rejections would be greatly reduced. On the other hand, there could be a food product with specific characteristics like bulk, delicacy, or even seasonality of production. In this scenario, there could be higher inventory costs for bulky agro-food products compared to other products.[38,255,256]

Supplementary quality associations in agro-food product industry

Process control/standardisation and internal (quality) audits

Process control, more demanding than it seems, ranges from planning, controls, and specification, cleaning/waste management, handling, packaging and storage, corrective and preventive actions, to production trials and quality records. For instance, planning could range between short, medium, and long term, or even on a rolling basis but yet can still remain regular.[53] Further, process control is also very essential in (preparing) guidance notes of the agro-food industry because it considers all

production stages, from receiving raw materials to the delivery stage of the product. Serving as a key element of ISO9001 contents, a good process (control) would certainly delineate CCPs. The responsibility of process control within the agro-food industry rests with either the factory manager or production manager.[53]

Applicable to the agro-food product industry, the standardisation depicts a management (process) tool that constitutes largely of documentation procedures. Considering that the production line hold various processes, there would be technical criteria/specifics to ensure products, as well as processes, are designed with quality.[257] For instance, process standardisation would focus to minimise the variations in product/production quality. Provisions can therefore be made to ensure that analytical and operational procedures, equipment/facilities, machinery, and raw materials get standardised.[257] Instrumentation patterns demonstrate the goals and procedures aimed to accomplish the work, and classified as follows: a) Standards of Quality – parameters related to the quality of inputs, products, and raw materials; b) Operation Standards – manufacturing processes of products, technical control/operational parameters; and c) Standards Inspection – criteria/methods to assess the degree of achieved success in delivering activity/work, compared to planned levels of products quality, which can be carried out on either the raw material, finished product or the process itself.[257] Quality outputs can be realised through the wide range of process standardisation, e.g., improved product standardisation/product quality, cost reduction, simplification, and optimisation of production processes. Others include an increase in the technical capacity of process operations, reduction of inventory levels of raw materials/inputs, reducing preparation time of machines, etc.[257]

The internal quality audit program should be a participative type, which ensures that every phase meets up to the prerequisite quality certification standard, especially prior to the arrival of the external standardisation bodies/inspectors as well as their representatives. Essentially, the internal auditors need to undergo a very robust set of preparation/training, which involves quality and quality assurance processes, as well as documentation. In addition, the internal auditors must be guided through the (audit) review processes.[53] For the internal (quality) audit to be successful, it has to be thorough. This is because the internal audit serves as a vehicle that facilitates the constructive improvement of a given organisation. A successful internal audit is clearly a prerequisite in achieving quality certification standards. And for this to be actualised, it would be vital to have: a) an established procedure, that comprises checklist, audit, review, corrective action, and close-out; b) comprehensive training program for auditors; c) frequent/routine internal audit schedule(s); and d) company/establishment awareness of (internal audit) program purpose as well as (auditee) knowledge of the part played.[53] For example, an audit used in the halal production is largely described with the help of prescribed guidelines/standards, e.g., Malaysian Standard ACB-Halal Product. Hence, as certification organisations develop their own audit schemes, many companies employ Muslims to work at production sites to help serve as internal checks. The challenge of halal audit rests on how backward into the food supply chain the auditor has to go before been able to declare a product as 'halal', which would differ, from the acceptance of basic ingredients to the check of each ingredient at any given time.[230]

Benchmarking and harmonisation processes

The benchmarking process (with respect to the agro-food industry) would focus on quality standards.[17] Regardless of the internal or external types, benchmarking can be applied in three ways, namely: a) Process Benchmarking – better understanding about the process, compares performance against internal and external so as to delineate improvement/optimisation strategies; b) Strategic Benchmarking – compares strategies to strengthen planning, to delineate priorities; and c) Performance Benchmarking – collate information about the outcome of quality, and compare them internally/externally.[258] From the QM viewpoint, benchmarking and harmonisation largely work together. Benchmarking is considered 'a process of measuring the performance of a company's processes, products, and services against those of another business, seen to be the

best in class'. Benchmarking, therefore, aims to delineate internal pathways for quality improvement.[259]

On the other hand, the harmonisation process (with respect to the agro-food industry) would aim to minimise either the redundancy process or conflicting standards that might have evolved, independently. The major aim of harmonisation is to establish common areas that are critical/essential, so as to attain a unified standard.[260,261] Moreover, the increasing complexity about 'global quality standards' and growth of 'competition/trade' within agro-food sector greatly influence benchmarking and harmonisation, with the associated quality standards like a) Benchmarking for mutual acceptance between different standards; b) Benchmarking of standards to develop an additional checklist; c) Establishing task force for participative and with representative quality standards for benchmarking; d) 'One-way' benchmark, where certain quality standard serves as a basis for benchmarking of another standard; e) Developing main criteria for benchmarking quality standard; f) Coordinating as well as improving audit activities including internal/external audits; and g) Developing new standard with the harmonisation of different standard requirements.[17,262–264]

Traceability in food quality and safety contexts

Widely practiced across various institutions, traceability remains a useful candidate that locates the root cause of particular quality/safety concerns. Regardless of the production stage, the traceability is largely based on products' recorded information.[257] In the agro-food industry, the traceability concept remains very relevant to initiate improvement as well as prevention actions, to deter the emergence or repeat of a specific problem.[257] With respect to food quality, traceability provides a history of production, application, or location of any (food) entity, by means of recorded identification as well as (overall) product distribution.[47,215] With respect to ISO9000 standards, traceability extends to the identification of the origin of materials or parts, the processing history, etc.[215] The

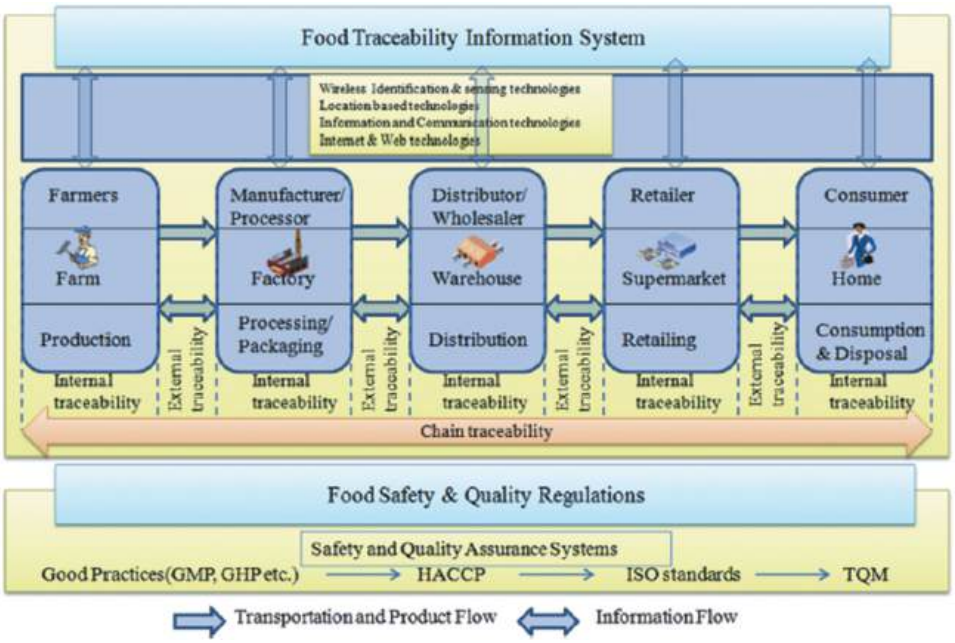

Figure 9. The conceptual framework of the food traceability system. It shows the scope of chain traceability captures internal and external aspects, simultaneously adhering to food safety and quality regulations, which the food industry sustains by engaging good practices, HACCP, ISO standards, which eventually cumulates to the cycle of total quality management (TQM) (Source: Aung & Chang [215] with permission from Elsevier Science).

efficiency in traceability can balance the benefits with the costs, as characterised by three key players, namely, the breadth (i.e., the amount of information collected), depth (i.e., how far back or forward the system tracks the relevant information) and precision (i.e., degree of assurance to pinpoint a particular movement of a food product). Further, traceability tool is key to motivate the need to answer such questions like: 'who' (i.e., actor/product), 'what' (i.e., actor/product information), 'when' (i.e., time), 'where' (i.e., location), and 'why' (i.e., cause/reasons) with regards to food quality, safety, and visibility.[215]

By regulating the compliance of food safety requirements, the traceability process would provide an effective quality safety monitoring system capable of increasing consumer confidence as well as connecting consumers with producers.[215,265,266] Essentially, traceability stands among legal requirements, which when adopted largely targets to improve food safety particularly within the supply chain.[85,267] Although food safety attributes are rarely commented to consumers, traceability continues to be among production processes that firms include, somewhat like a standard safety check within their quality standard platform.[268] Other authors have considered traceability among process indicators that enhance product quality of agro-food products.[269–271] When the traceability of products increases, consumers can rapidly evaluate the food product quality to increase the transparency of the production process.[85,272] Both QA and traceability increasingly top the priorities of food retailers, as the latter continually strive to take extra steps to ensure food safety. Both QA and traceability can be achieved through a consistent yet high quality/robust supplier – involved QA program.[84,273]

The conceptual framework of the food traceability system, is shown in Fig. 9. As an information driven-kind of system, information technology is shown as incorporated to facilitate both internal and external traceability components. In addition, the food safety/quality regulations and quality assurance systems function throughout the chain traceability space, from the farmers' production to the consumption stages.[215] To have a good understanding of traceability regulations/standards, the food industry must have food quality safety standards. From a legal/regulatory standpoint, the exchange of food traceability data is important to achieve a transparent and smooth transfer of information among the food supply chain actors.[215] Further, the documentation procedure as part of the traceability is vital within the food establishments' internal process, which can include: a) external discharge (ED); b) VAT invoice; c) Trade Identification Document (TID); d) Inter-Warehouse Transfers (IWT); e) Internal Dispatches and Deliveries (IDI and IDE).[43] Considering the increasing popularity of food safety (GHP, GMP, HACCP, etc.) and quality (ISO 9000/22000) systems, the traceability systems are very vital especially in tackling the growing consumer concerns associated with food quality and safety challenges.[47]

Besides enhancing the food safety standards, traceability can help the food industry become economically vibrant given its robust tracing system, which is able to identify with the specific sources of problems.[31] For instance, fresh produce traceability (FPT) has documented instructions as developed by the EHI Retail Institute, European Association of Fresh Produce Importers (CIMO), Euro Retailer Produce Working Group (EUREP), European Union of the Fruit and Vegetable Wholesale, Impact and Export Trade (EUCOFEL), Southern Hemisphere Association of Fresh Food Exporters (SHAFFE).[31] To help make traceability more effective/efficient, there is appropriate software under consideration, which could help to ensure the agro-food establishment/firm is effective in managing product quality, particularly in tracing the products' origin as well as quality.[43] In addition, the companies must be attentive to the bar code/number application of registered authorities/framework, so as to enhance the tracing of the fresh produce.[31]

Food inspection process and laws/legislation: Some essentials

a) Food inspection process: Some highlights

Food inspections are aimed to identify quality improvements, for example, in food-related projects. With respect to food quality/safety, inspection requires planning, prior to implementation,

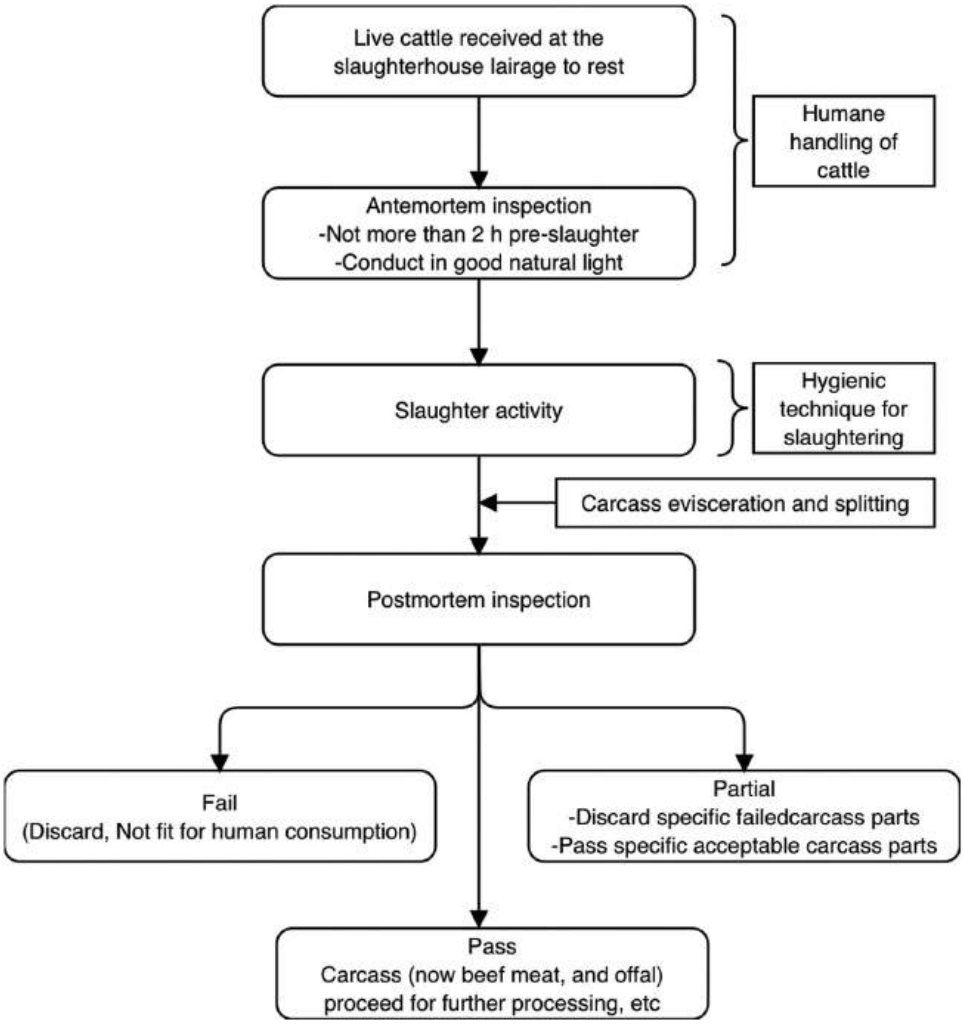

Figure 10. A schematic representation of the basic meat inspection activities involving cattle slaughter in a typical slaughterhouse in Nigeria. The figure shows the humane handling of cattle and hygienic techniques for slaughter before and after antemortem inspection. The postmortem inspection would provide three major outcomes to the eviscerated/split cattle carcass/beef meat, which include either fail, partial, or pass (Source: Okpala, Nwobi & Korzeniowska [275]).

followed by monitoring action/activities – a never-ending cycle of quality improvement, which constitutes a part of (total) quality management.[94] Food inspection should not be confused with an audit. This is because the (food) audit (whether internal/external) aims to certify the manufacturing quality of food products, which largely involves product manufacturing, GMP, product quality, and HACCP.[274] Either official or unofficial, the food inspection remains very crucial as a food quality safety/management machinery. In Nigeria and specific to the meat industry as an example, there is the meat inspection process routines conducted by veterinarians across various slaughterhouses. The meat inspection process itself is a food safety and compulsory QM activity. A schematic diagram of the basic meat inspection process in a typical abattoir/slaughterhouse in Nigeria, which involves the cattle slaughter activity is shown in Fig. 10. The key stages include the assembly of live cattle at the slaughterhouse lairage, to conduct the slaughter process, the evisceration of the carcass, and being split into desired portions, towards preparation for sale/storage.

Herein, the crux of (bovine) meat inspection shows two major well-known facets, which include both antemortem and postmortem aspects.[275]

In Poland for example, the EU and national food laws have provisions that are regulated through the (food) inspection systems, and its implementation is officially supervised by the state inspectors.[47] Notably, the most important aspect of the food inspection, from the consumers' perspective, is the permit to release of the final food product(s).[240] Besides, the food inspection directly associates with QA systems, although the latter is of voluntary implementation. Despite this, the food quality should be subject to the inspection, specifically, to ensure the consistency as well as conformity between the actual product qualities, as declared by the food chain sector.[47,274] In addition, the food inspection appears to occupy a useful space within the ISO standards, particularly in the process management and control.[183]

b) Food laws: Some historic contexts

The rapid urban population growth, public health concerns, and new distribution/innovative food supply chains are among major bottlenecks confronting food production, which brought about the creation of food laws.[160] The 1860 voluntary act for 'Preventing the Adulteration of Food and Drink' in England was the first comprehensive food law. This 1860 voluntary act got replaced by a mandatory act in 1875. Between 1897 and 1971, the Codex Alimentarius Austriacus under the Austro-Hungarian empire developed a collection of standards and product descriptions. Strictly speaking, these (collection of standards), not legally enforceable food standards, lent its name to what it is called today, that is, 'International Codex Alimentarius Commission'.[160] In the USA, the Pure Food and Drugs Act of 1906 became the first major federal consumer law, specific to food processing, which prevented the interstate and foreign commerce of adulterate and misbrand drinks/foods, as well as consumer fraud/poisoning. However, there was a loophole in the Pure Food and Drugs Act of 1906, which in the subsequent years allowed poor quality food products and deceptive packaging to thrive. By 1938, the Food Drug and Cosmetic Act, which replaced the 1906 Act, appears to be a law that provided the foundation for subsequent (food) legislative standards.[160] In the EU, the Directorate-General for Health and Consumer Protection keeps food safety laws up-to-date, properly enforcing it across the member countries.[156] In 2002 for instance, the EU adopted the principles of food safety in a regulation called General Food Law Regulation (EC) No 178/2002, which constituted stringent measures/regulations on the release, marketing, labelling, and traceability of foodstuffs. Besides, the Directorate-General for Health and Consumer Protection depends on the European Food Safety Authority (EFSA) to provide scientific data on food safety. Compared to US counterparts, EU food safety organisations possess more legal authority over (agro)food produce.[156]

Essentially, the EU Food Law involves chemical safety, food contents/ingredients, food product description, hygiene and sanitary conditions, and a number of other (food) product regulation specifications. Notably, EFSA coordinates EU Food Laws. However, every EU nation possesses its own (national) regulatory body.[31] In addition, food laws do have some level of universality, which makes them globally comparable and legally binding. Clearly, food risks in one country would become a burden to all. For example, 1990 Food Safety Act of UK, Public Health Act 851 of Ghana, 1992 Food and Drugs Law of Ghana – all emphasise the illegality to sell unwholesome food, adulterated food, food prepared under unsanitary conditions, and the need for authorised persons with the technical know-how to supervise the food production process.[163] Globally, countries make an effort to update food control laws, combine legislation on food quality and safety with effective programs. Many countries continually propose strategies to confront the challenges mitigating enforcing food laws, via further training of food inspectors, the establishment of research/development support facilities, etc.[25] Food legislations allow authorised persons/companies to check consumer food products and ban them if they do not meet safety requirements.[31]

c) Food legislation and enforcement: Some briefs

EU legislation help ensures food operators are responsible for food hygiene/safety targets to ensure public health/protection. Food law regulations would continue to incorporate HACCP principles.[127] The EFSA established by Regulation No 178/2002 of the European Parliament/Council of Europe laid down general principles/requirements about food law/procedures in matters of food safety.[43] As part of quality control, food law guides food safety programs. For example, such programs like GMP, HACCP, British Retail Consortium (BRC), and Global Food Safety Initiative (GFSI) help enforce food laws within the food industry.[276] Another example worth mentioning is the EFSA published simplified FSMS for certain small food retail establishments. Indeed, developing similar FSMS requires a fundamental understanding of processing activities/stages that have the capacity to increase the occurrence of hazards.[277] This simplified approach can also help in achieving control using PRP effective FSMS activities, which can include critical limits and record keeping, when required.[278]

As enforcement of food laws remains the responsibilities of governments, the implementation of food safety procedures is oftentimes tied up within such food laws, being imposed by (Federal and State) regulatory bodies/frameworks.[84,91] In regulating and sustaining food quality, food laws help to assure consumers that food product purchased is safe and meet their expectations. The food laws, with respect to the principles of distribution/production of raw materials, foodstuffs and its (direct) contact objects, can overlap the set of legal norms. In addition, food laws can be focused towards attaining the level of protecting consumer health as well as fulfilling the food safety expectations.[47,91,279] In foodservice establishments/units, the compliance to food laws (and food safety/industrial practices) can be limited by such factors as absence of effective enforcement/consumer pressure agencies/groups, lack of management interest and motivation as well as lack of resources and technical knowledge.[163]

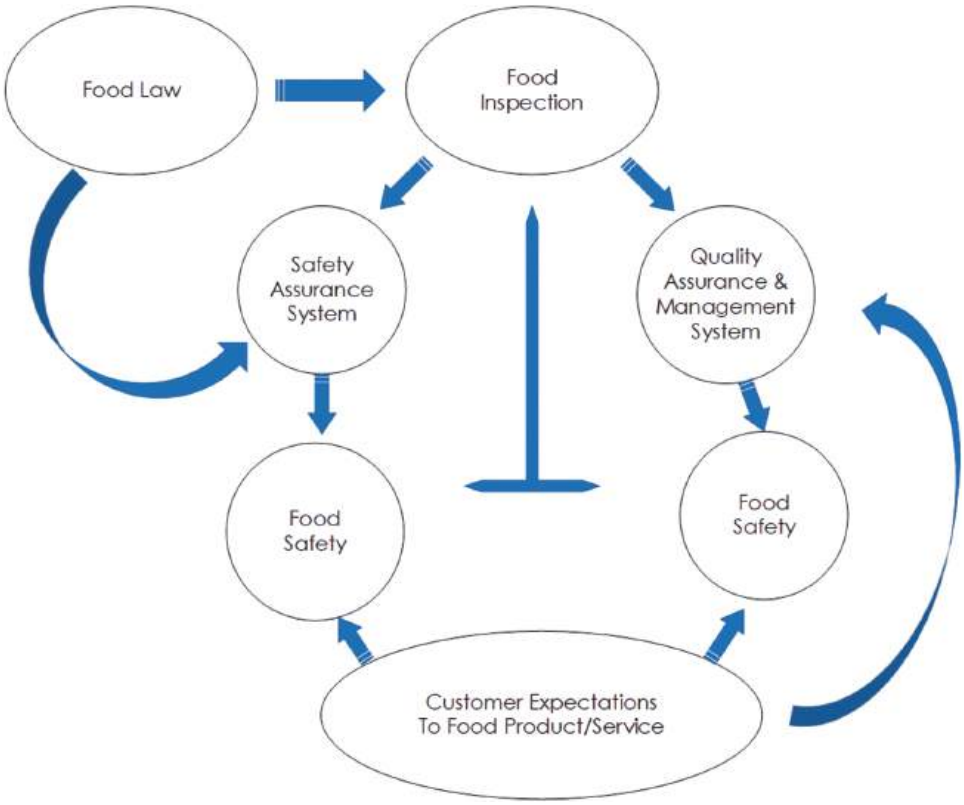

Figure 11. Integrated schematic flow linking food law, food inspection, quality and safety assurance, with consumers' expectations regards to food safety and quality (Source: Sikora & Strada [47]).

d) Integrating food law, inspection with quality safety: Some briefs

Integrated schematic flow linking food law, food inspection, quality, and safety assurance, with consumers' expectations regards to food safety and quality, is displayed in Fig. 11.[47] Here, the food inspection can be seen to directly connect to safety assurance, food quality, and can as well extend to QM. This can point to why the inspectors' role, working within the confines as prescribed by both legal and regulatory frameworks, to implement the food law, is important.[47,274] Fig. 11 also shows that the customers can equally contribute through feedback mechanisms, to improve the food product quality/safety. Ultimately, the feedback mechanism aims to enhance the entire/overall inspection process. Indeed, this mechanism/pathway would provide the platform for inspection officers/agencies to put forward constructive suggestions, which they have delineated from the challenging aspects of (existent) food laws/regulations. Depending on the changes as well as dynamics in the quality/safety implementation processes, it can be presumed that the inspection officers/agencies would proffer their constructive suggestions, which can lead to useful amendments to any challenging aspects of (existent) food laws/regulations. In addition, the implementation of food laws exclusively rests on the safety assurance systems such as GHP, GMP, and HACCP.[47,91,274,279]

Risk assessment in food quality and safety: Fundamentals, levels, phases and scope

Risk assessment involves a systematic process of identifying, organising, and analysing information about risks so as to acquire clarity and consistency in presenting available as well as practical decision-making data. Generally, decisions involving food safety requires defining the risks as well as applying specific regulatory sanitary measures.[83] Largely, risk assessment in Europe is guided by EFSA, which help to communicate food safety topics to support risk managers at the European Commission (EC), European Parliament and EU member states.[189] Although risk assessment can apply to diverse food safety areas, it can be more specific too, e.g., developments that assess risks associated with a particular food product, or food-hazards combined within food safety management systems.[280]

a) Risk assessment in the HACCP concept

As a risk assessment tool, HACCP considers (food) contamination as a whole, whether intentional/unintentional. HACCP approach involves the development of an operational prerequisite program (OPRP), which targets to control the likelihood of introducing food safety hazards and/or

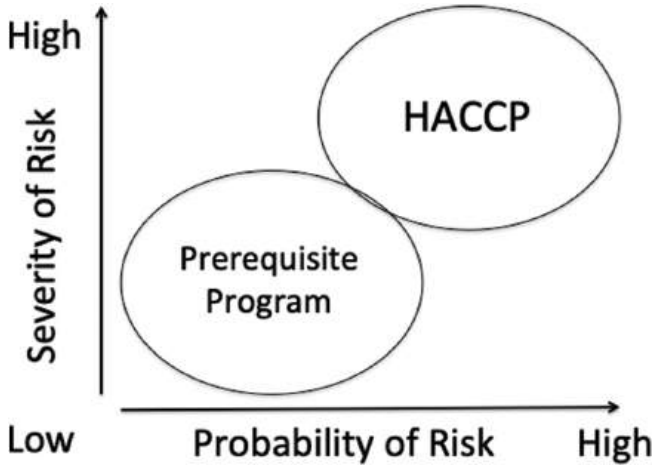

Figure 12. Risk assessment within the HACCP concept, presenting low/high probability and severity levels. Both risks within the prerequisite program and HACCP circles can bring about severe health conditions/situations (Source: Bennet & Steed [183] with slight modifications)

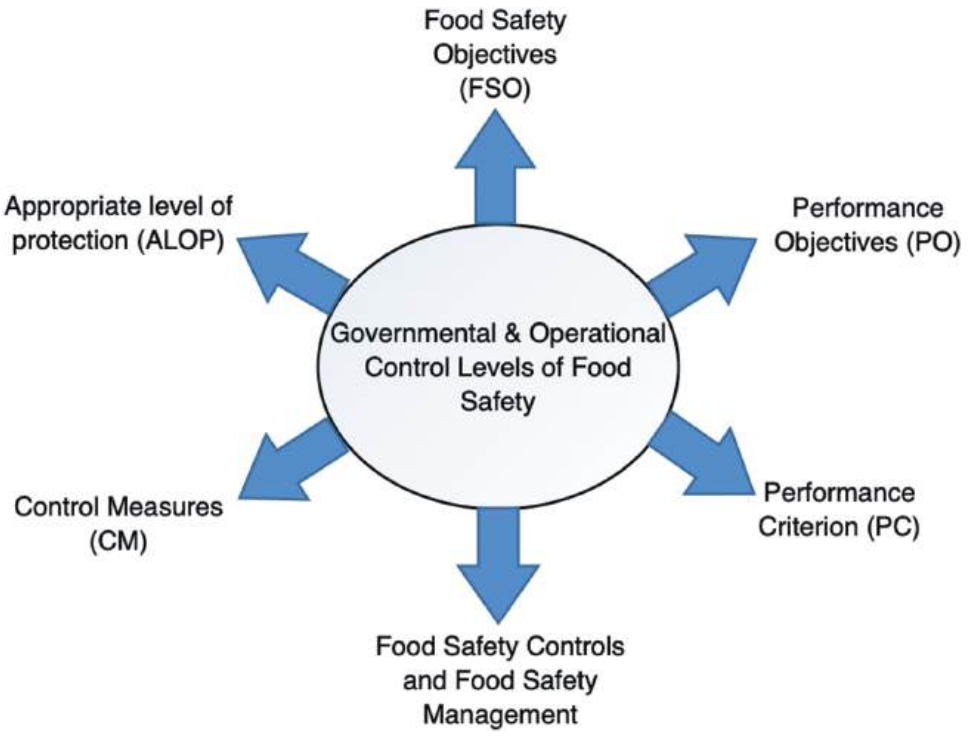

Figure 13. Risk assessment criteria based on food control (Source: Aruoma,,[23] with slight modifications, [permission from Elsevier Science]).

contamination of (products) food safety hazards.[281] Besides, adulteration makes food products fall short of legal standards, which eventually makes them to become unsafe and not wholesome,[282] which points to risk assessment from the HACCP perspective thus very relevant. The risk assessment probability and severity levels associated with the HACCP concept is shown in Fig. 12. Both the low and high probability and severity levels can be seen. Additionally, the prerequisite program(s) and HACCP circles/domains can also be seen. Outside these circled areas within the graphical space is occupied by the greater challenges, which involve biological, chemical, and physical risks.[183] Either the high probability/low severity or low probability/high severity would bring about illness/injury, which makes the evaluation of total preventive systems against any potential hazards highly warranted. For example in a given meat/poultry operation, despite the low chance of probability of a known pathogenic microorganism, the severity could remain very high.[183] Besides, risk assessment has been shown with the capacity to employ the Failure Mode and Effective Analysis (FMEA) model, which allows for the streamline of product development processes, especially from the ethics and legislation perspectives, very much applicable to a variety of food processing plants.[283–285]

b) Risk assessment criteria based on food control

The risk assessment process should provide an estimated impact, as well as the probability of adverse health effects attributable to potentially contaminated foods.[286] The use of HACCP concept/framework together with microbiological risk assessment can help in evaluating the health status of a given population and its corresponding food product as well as product group, which associates with for instance a specific (foodborne) pathogen.[23] The risk assessment also provides an absolute as well as relative indication of risk to a given population, regardless of the origin of the food product. Risk assessment criteria based on food control, is shown in Fig. 13.[23] The terms used in this figure require some explanation. An appropriate level of protection refers to the level of protection deemed

appropriate by the member (country) establishing sanitary measures to protect human, animal, or plant life within its territory.[23,176] Food sanitary objective (FSO) can refer to the maximum frequency of hazard in giving foodstuff at the time of consumption, which contributes to the appropriate level of protection (ALOP). FSO remains an option that provides guidance to food safety management, as expected in managing risks.[23] Performance objective (PO) refers to the maximum frequency of hazard in giving foodstuff at a specific stage within the food chain before the time of consumption that contributes/provides to an ALOP/FSO, as applicable.[23] Performance criteria (PC) explain the effects in concentration/frequency of hazard(s) in food(s) that must be achieved by the application of one or more control measures to contribute/provide to PO or FSO.[23] Control measures (CMs) refer to any action/activity employed to either eliminate/prevent food safety hazard or reduce it to an acceptable level, which can include microbiological guidelines/specifications on hygiene codes, microbiological criteria, pathogen control, as well as (other) specific information, e.g. labelling, training, education, etc.[23]

c) Risk assessment as food science-based investigation

By connecting communication with management, risk assessment can involve the initiation of processes, prior to the evaluation of results.[176] Food safety officers inspect food establishments, and this should be a fundamental practice in national food standard agencies. The food safety officers also coordinate with the food business operators, in order to introduce the food safety systems, especially in new premises. The food safety officers are able to carry out these duties given their training in understanding hazards and risk management associated with a variety of food products, production and related processes. The food safety officers have a well-documented roles as well as responsibilities within food safety regulatory framework, which can include: a) inspection with respect to license requirements; b) maintenance of database per food business operation; c) preparation of food safety plans; d) response to incidents related to food poisoning, and e) sample collection for testing.[176] In a given national food system, risk assessment – a food science-based investigation that forms a significant portion of risk analysis framework as shown in Fig. 14, comprises of steps namely: a) hazard identification; b) exposure assessment; c) hazard characterisation; d) risk characterisation; as well as e) scope of risk assessment.[23,176,286,287] We will succinctly mention them subsequently, so to understand what they all entail.

Hazard identification, largely, is considered a preliminary yet qualitative evaluation of analysed information . It equally considers the contexts of both chemical and microbial risk assessment. For instance, the initial action of the microbial risk assessment will determine major exposure sources to the pathogen, or determine which pathogen(s) might be of an issue specific to a given food/food commodity group.[286] *Exposure assessment* estimates the exposure likelihood of an individual/population to microbial hazards. It also considers the microbial load likely ingested, as well as where the unit of exposure typically is per meal portion size. The characteristic of pathogen agent, initial contamination of raw material, level of sanitation/process controls, methods of either distribution, packaging, processing, and or preparation, the microbial ecology of food as well as storage of foods, are among influential factors the risk assessor must consider.[286] *Hazard characterisation* requires understanding how the disease incidence would depend on such factors like attributes of food that alter host/microbial status, general health/immune status of hosts, number of ingested cells as well as virulence characteristics of the pathogen. As human population response to foodborne pathogen exposure highly varies, any microbial dose–response would consider various modes of pathogenicity associated with different (pathogenic) foodborne bacteria. If the causes of disease were not fully expatiated, the knowing host/food matrix effect/influence on pathogenicity would be difficult.[287] As the final stage in microbial food safety risk assessment, the process of *risk characterisation* is where the exposure and dose–response assessment jointly provide an overall evaluation of the likelihood that the population is likely going to adversely suffer owed to the hazard outcomes. Therefore, the risk characterisation targets to communicate the confidence level that risk assessors have in their analysis. Adding to the overall interpretation of results, the risk characterisation would summarise the impact though critical

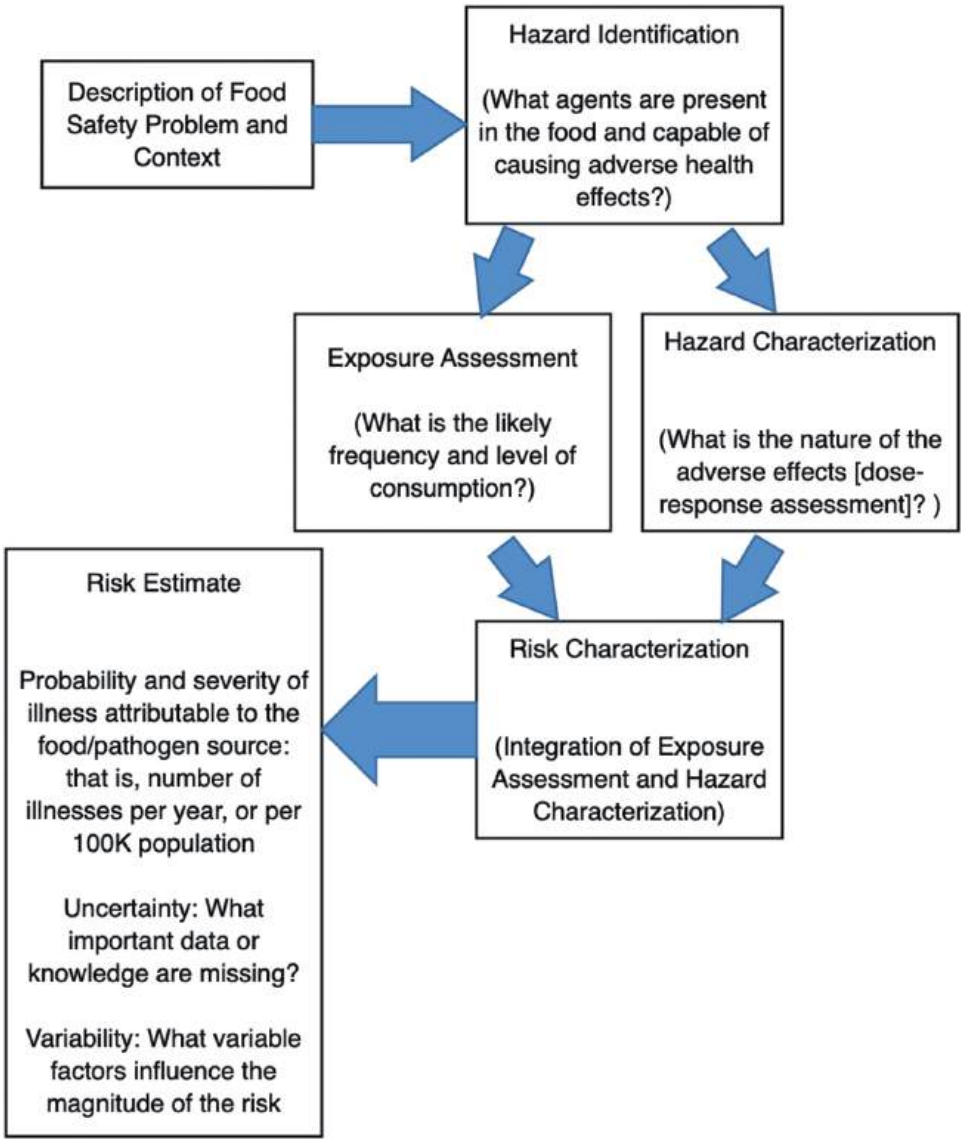

Figure 14. Risk assessment remains a science-based investigation that forms a significant portion of risk analysis framework (Source: Aruoma, [23] with slight modifications, [permission from Elsevier Science])

assumptions, together with decisions of developing the exposure and dose-response would have on interpreting the overall assessments.[287] Additionally, the *scope of risk assessment* depends on the (risk) management question and reason for performing the assessment. The identification source must be authentic, with a clear risk profile description through a food safety problem/context. Through consultations, the assessor(s) and manager(s) must ask the right question(s) that guides the direction/selection of information throughout the risk assessment process, which helps food safety follow both qualitative and quantitative pathways.[286]

Validation and verification processes in food safety

By definition and in the context of food safety, validation refers to the effectiveness of managerial and technological control measures,[37] which considers well designed and systematic method that assures the system performs consistently with the design specifications.[288] Validation helps to determine as well as ensure that the intended result is achieved, which from the HACCP standpoint indicates that hazards are controlled at each CCP.[155] Validation is checked in advance so to attest it is: a) judged in an objective way that requires real data and or independent people; b) specific for food production situations; and c) supported by scientific evidence. Validation can include obtaining evidence about one (or a combination of) control measure(s), and if properly implemented, controls hazards associated with a given specific outcome.[37] From the analytical perspective, validation can interpret whether the analytical purpose of the method is achieved, by obtaining results with an acceptable uncertainty level. Validation in the analytical sense forms the first level of quality assurance in the laboratory and therefore ensures the analytical method is fit for purpose.[289] Ideally, validation is done prior to implementing a valid HACCP plan. Once validated, the food product is considered as fit for purpose, such that CCPs would control identified hazards to make its occurrence become rare.[288] Many information sources used to validate the CCPs help establish critical limits, for example, scientific literature, government regulations, etc. The validation process can end with mandatory/compulsory periodic revalidation of HACCP plans, to confirm its validity.[155] In addition, validation plays a key role in GMP, to ensure that facilities/equipment, processes, test procedures are under control to consistently produce quality outputs.[152] Additionally, the EU and the US within their legislations have adopted procedures for HACCP validation and verification.[154]

Besides continuous auditing and verifying within the HACCP system, there is initial validation and revalidation. Importantly, the individual conducting the food safety audit is not the same determining the corrective actions. This ensures some degree of impartiality.[26] By definition, verification in this specific context would refer to procedures carried out to validate the effectiveness and suitability of the HACCP system.[240] Also, US National Advisory Committee on Microbiological Criteria for Food (NACMCF) defined verification as the use of methods, procedures, or tests in addition to those used in monitoring to determine if HACCP system is in compliance with the HACCP plan and/or whether the HACCP plan needs modification/reevaluation. What is being verified is the HACCP system, what is being validated is the HACCP plan.[155] As a determination of correctness, verification helps to confirm objectively that the evidence about specific requirements has been fulfilled. Similarly, it is applicable to methods-related performance to check for the effectiveness of intervention/preventive facilities, for example, hygiene design, etc.[37,39] It also involves prerequisite programs (PRP) that support HACCP, followed by observations and interviews of people, who calibrate equipment, monitor, and review the CCPs.[26]

Besides confirming that the specific requirements have been met in its entirety, the verification checks after implementation/utilisation of managerial and technological measures if the control activities already put in place have been operating as designed. Further, checking must be done in a reliable/valid way.[37,39] Verification methods/requirements can include: a) routine review of control and monitoring results; b) reviews of the quality of the in-process and final product as determined by product analysis; c) review of results of shelf-life assessments/products; and d) review of customer complaints.[240] As an internal process conducted by the food/industrial plant/regulatory body, the verification process runs continuously with auditing of the HACCP system in adherence to plan and scheduled with the prerequisite framework of regulatory agencies.[155] Verification – applicable to halal products, ensure the food industry meets (halal) food production requirements with prescribed religious criteria, which is usually through a combination of audits and laboratory tests.[230]

Personnel/staff assessment and (further) training

An assessment of staff within the agro-food industry has several phases and would commence when assessors are appointed either internally or externally. Documentation activity help verifies that all aspect of the quality standard is being addressed. Dependent on the QM program and quality certification standard being targeted, assessment should implement the corrective action based on deficiencies (initially) established.[53] From the food safety and quality standpoint, the assessment procedures can feature three potential outcomes, namely: a) Serious deficiencies found, such that certification to the standard cannot be recommended; b) Standard lacking minor details, which leads to recommending a certification to the standard after corrective action; and c) No problems is found, which allows for a complete recommendation of certification to the standard.[53] To attain a successful assessment, a food firm/unit may find the competencies and incorporation of the internal quality lead assessor and verifier useful, particularly to chair the assessment house so as to equip the agro-food unit/establishment with the relevant quality assessment/certification procedures towards the desired standard. Further, the assessment procedures would certainly require adherence to a prescribed/specific document format. After the certification of the desired standard has been achieved, surveillance visits can then be planned to check management's consistency in sustaining QM standards.[53]

Within a given agro-food establishment, staff should embrace all forms of internal assessment to help measure competencies and strengthen the commitment to the job role. An objective/thorough assessment would enable top management to identify areas where further training of staff is necessary. Bolton [53] reported the great benefits of having the qualified personnel. Importantly, the qualified personnel are able to fulfil the job role and perform adequately within the given agro-food product unit. In addition to identifying the required training needs, the documentation records are expected to outline the staff's experience, qualifications, and training required to execute the job role. Besides, in-house training should cover food hygiene, knowledge of national food safety law/regulations, consistent with the job instructions. Adding that every staff should have a training record, departments should document the assessment of skills capability of staff, together with an annual review of training requirements.[53] Another context that demonstrates the importance of personnel development can be seen in the work of Okpala, Nwobi and Korzeniowska.[112] These workers studied butchers in a typical Nigeria slaughterhouse as it pertains to their knowledge and perception of GHP and GSP. Butchers, besides being very conscious of their knowledge and perception of GHP and GSP, have to strive to continually improve their slaughterhouse services to assure beef quality and consumer safety.

Challenges/Non-conformities encountered during the auditing process of food safety management systems

Implementing FSMS and its certification remains a very crucial strategy that helps ensure food safety in both private and public (food) establishments. The implementation process is necessary to ensure competitiveness and improve quality assurance systems. Food establishments, largely those at the small-scale level, to implement FSMS are confronted with challenges like huge costs and lack of financial power, lack of international market, uncertainty about the potential benefit of FSMS, as well as lack of consumer awareness of FSMS benefits, [290] all of which can influence the auditing process. Broadly, the auditing process in the food industry is divided into internal and external facets. The internal audits involve those conducted by internal auditors that work for the organization. The external audits involve those conducted by a third-party organization.[291] Audits can be grouped based on auditor–auditee relationship, which brings about first-party (self-assessment), the second party (proprietary audits), and third party (conduction of audits by independent auditors that often leads to certification) audit types.[26,292]

Djekic, Tomasevic and Radovanovic [293] investigated the quality and food safety issues associated with certified food companies in three Western Balkans countries via a survey method, which involved analyses of audit reports that specifically targeted nonconformities and/or improvement opportunities

from 123 food quality/safety audits across 60 food companies. The QMS audits revealed the management process (21.8%), before control (14.5%), increasingly related to documentation and control of records. Within the (food safety) audits, managing food safety issues (17.5%) and various aspects of food safety control (15.5%) were noted. Besides prerequisite programs including GHP requirements occupying majority of findings (59.6%), the audits would generate twice as much nonconformities compared to those of QMS audits. Kotsanopoulos and Arvanitoyannis [26] similarly concurred that managing and control of food quality /safety were among key concerns that needed attention in the food industry. The auditing process, therefore, has to be specifically geared to assure food safety. By investigating the food supplier qualification, Losito et al. [294] evaluated the auditing system and non-conformances within an Italian large-scale-distributor. In particular, what underpinned their study included the fact that the suppliers for large-scale food distributors were required to meet many specific requirements, and had to undergo audits so as to assure the hygienic and sanitary quality of their (food) products. These workers revealed that the major non-conformances involved "management systems" at higher rate, and that large food plants applied the HACCP principles better compared to the small enterprises. These workers provided an example of a checklist that could detect the non-conformances status of its food suppliers, as well as information on HACCP system management.

Djekic et al. [295] delineated the benefits and constraints associated with improving confectionary industry supply chain through second party audits. Their investigation involved second party audit using a developed quantitative quality/food safety (audit) tool, and the audit program involved flour mills and food packaging producers. Their findings showed that certification status does not necessarily imply high performance of a quality/food safety system. Further, their findings showed that companies could experience challenges in identifying processes, setting performance indicators, as well as implementing problem-solving tools. Additionally, their work considered quality control as essential because there were cases where companies did not document their control methods, and had no method in place to verify the consistency of their results. Overall, the main food safety constraint via the audit was shown to be HACCP implementation. Albersmeier et al. [296] evaluated the reliability of third-party certification in the food chain, which ranged between checklists to risk-oriented auditing. Their work was based on a database analysis of the German certification system Quality and Safety (QS) as well as workshop with the QS-certification bodies that conduct about 85% of all agricultural audits. These workers were able to deduce the first empirical hypotheses regarding what connects the reliability of third-party certification with those of the institutional framing of standards. The premise for their study was that certification is increasingly relevant for agribusiness, and that in Europe, substantial parts of the value chain are already certified by standards like International Food Standard (IFS) or GLOBALGAP (the former EurepGap).

Challenges/Determinants encountered during the implementation of food safety management systems

The determinants of food safety management systems (FSMSs) and their implementation can be market-based, or rather, market-driven.[297] By implementing food safety management systems (FSMSs), it is possible for food companies to respond to real and perceived food safety hazards. For emphasis, the FSMSs are largely public-based like ISO 9001, ISO 22000, Hazard Analysis Critical Control Point (HACCP), as well as industry-based like GlobalGAP, British Retail Consortium (BRC), Safe Quality Food (SQF), International Food Standard (IFS), and Food Safety System Certification (FSSC). Challenges that face the FSMS, especially with respect to implementation, which is also applicable to QMS, underpinned by two factors, internal and external. Internal factors include the perceived economic incentives and disincentives. External factors include the industry and regulatory pressures. These two (internal and external) factors affect the firm, process, and product characteristics.[297] Other useful barriers that hinder the implementation of FSMSs include: a) Lack of willingness by other supply chain partners to participate in the implementation of FSMS; b) Lack of

Table 5. Differentiating ISO9001 and ISO22000 in terms of ownership, standard, adoption scope, global total valid certifications/sites, and global scale

Items	ISO 9001	ISO 22000
1. Ownership	Public	Public
2. Standards	International	International
3. Adoption scope	Across all industry types	Applicable across the food supply chain
4. Global total valid certifications/sites	883,521/1,217,972**	33,502/39,651**
5. Global Scale	Across the continents of the globe	Across the continents of the globe

Source: ISO Survey 2019 [227]; Abebe et al. [297]; ** Based on ISO Survey 2019 data.

clarity about the benefits to be gained from implementing FSMS vis-à-vis required investment costs; c) Lack of trained staff for technical and management aspects of FSMS; d) Expensive and complicated task (i.e., there are economic, technological and legislation constraints); e) Resource-intensive, require much administration and paper works which place a burden on companies; and f) Lack of complete, accurate, timely, and easily accessible information about the need for FSMS.[297]

Karaman, Cobanoglu, Tunalioglu, and Ova [298] identified barriers of implementation of FSMS among Turkish dairy industry like lack of knowledge relating to, as well as cost of HACCP and other food safety programs. These workers suggested that periodic training and consultation services for FSMS applications specific to the dairy industry by the government, together with financial support was needful. Vladimirov [299] analysed the factors of implementing efficient FSMS in food retail sector and food industry in Bulgaria, and found that some infrastructural difficulties as well as perceived negative effects of the the official control were main challenges. Macheka et al. [300] studied the barriers that influence implementation of FSMS in Harare Province, Zimbabwe. These workers identified key barriers such as inadequate facilities and infrastructure, lack of financial resources, lack of top management commitment, as well as size of organisation. Despite these barriers, it was found that the main benefit/motivation to implement FSMS was to increase employee skills, improve company image, and most importantly improve food product quality and safety. Investigating implementation of FSMS in the UK, Mensah and Julien [301] revealed food enterprises claimed that statutory regulations were biased towards consumers without the conduct of adequate impact assessments on all stakeholders within the food supply chain. These workers opined that this bias would cause the food

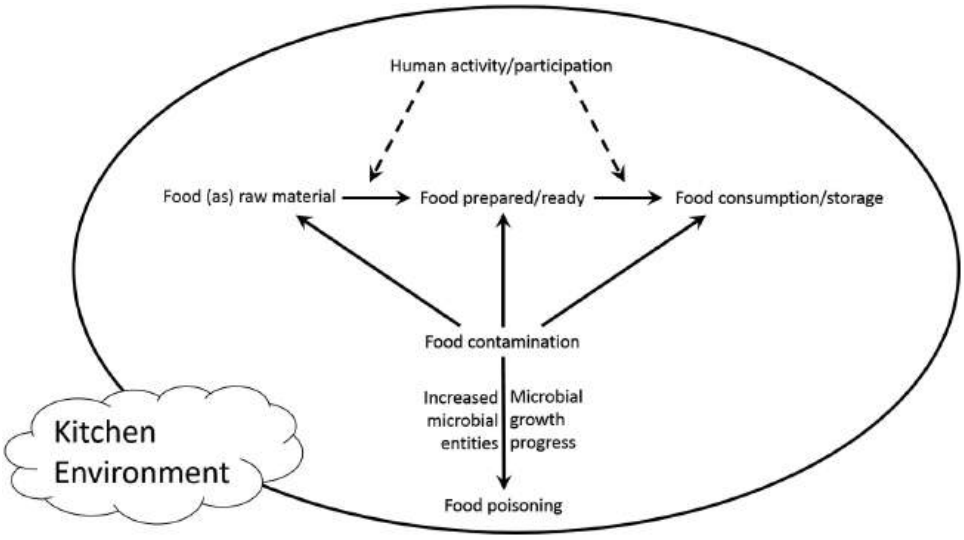

Figure 15. Schematic diagram showing human activity/participation during food (as) raw material, preparation, and consumption stages, adding food contamination that can progress onto poisoning, all within the kitchen environment (Source: Okpala & Ezeonu [29]).

industry to incur significant costs that could others be avoided. Additionally, the cost of non-compliance was considered as significant to enterprises despite that compliance with food safety regulation remained burdensome.

Understanding the extent of FSMS implementation with respect to ISO9001 and ISO22000 requires differentiating the two based on ownership, standards, adoption scope, and their global scale, and this is represented in Table 5. Both ISO9001 and 22000 are public and under the international standard framework (that is, the International Standard Organization). The difference is that, whereas the adoption scope of ISO9001 cuts across all industry types, the ISO22000 is applicable across the food supply chain.[227,297] That is clearly why there are more ISO9001 valid certifications and sites over the ISO22000 ones. Therefore, the domestic market environment would have a role to play in order to connect well with the industry-based FSMSs. This is because the domestic market environment is largely dominated by small (traditional) retailers.[302] Indeed, the industry-based FSMSs appear to be more heterogeneous as well as stringent and thus, entail higher compliance costs.[87,297,303] Another concern is that the FSMS implementation requires a high level of organizational commitment for it to be fruitful.[40,304] Having a QA unit in the food firm can be very useful, and if absent, may hinder FSMS implementation.[305] Equally, the education level of the QA manager can be an obstacle to the full implementation of FSMS in a given food enterprise.[297,305]

Some reflections into the relevance of QM in progressing food hygiene quality safety standards and related processes

Food industries around the globe are increasingly embracing various aspects of QM.[20] On the other hand, consumers continue to remain the ultimate judge of any (food) industry's quality performance.[306] Previous empirical studies we came across that gathered QM practice/performance data have largely been based on firms' perspectives.[8,306–308] Regardless of how mature the QM field is, future studies should incrementally aim to fortify its (QM) definition, which was founded by: a) addressing content via explicit identification of QM level (principles/practice/technique); b) striving for standardisation of definitional terms; and c) testing existent instruments that are able to measure QM practice dimensions.[1]

Good practices have to be part of human activities, which would be found in the activities surrounding food material preparation, and consumption/stages as depicted in Fig. 15. This is what Okpala & Ezeonu[29] believed in their review of food hygiene/microbiological safety in a typical household kitchen. In the home for instance, because the kitchen is where food is largely handled, this concept of food hygiene/microbiological safety should be reflected across other food preparation/production places[29]. This is because food contamination can take place at any stage(s) within the food supply chain, which if it started from the very onset of the chain can increase probability of (food) contamination, and eventually result in worst case scenario of food poisoning. Therefore, it is very important to reiterate herein that food safety and different good practices go together, regardless of human culture, history, and lifestyle. If good practices were analysed in a typical food operation/unit, three categories can emerge: a) Those directly connected with food technology, e.g. GMP; b) Those indirectly connected with food issues, e.g. GRP, GTP; and c) Those that deal with all activities concerning food handling, etc., e.g., GHP.[154] In food processing, the large number of good practices, whether it is GMP, GLP, GAP, GCP, GHP, etc., appears to interconnect with each other. For example, GCP sometimes finds itself embedded in GHP.[166] Besides, competency is a prerequisite in both quality assurance/management and food safety practice. HACCP personnel programs require employees to effectively manage CCPs. HACCP implementation requires highly motivated food hygiene managers who would develop/maintain a food safety culture.[68] In addition, enforcement of kosher standards varies in the Jewish community. Kosher's integrity is very important in the food supply chain.[236,237] Similarly, halal integrity is very important in the food supply chain. Any haram contamination /dishonesty with halal standards remains a great concern to Islamic consumers. This is because the Islamic consumers largely depend on the food industry/policymakers to quality assure

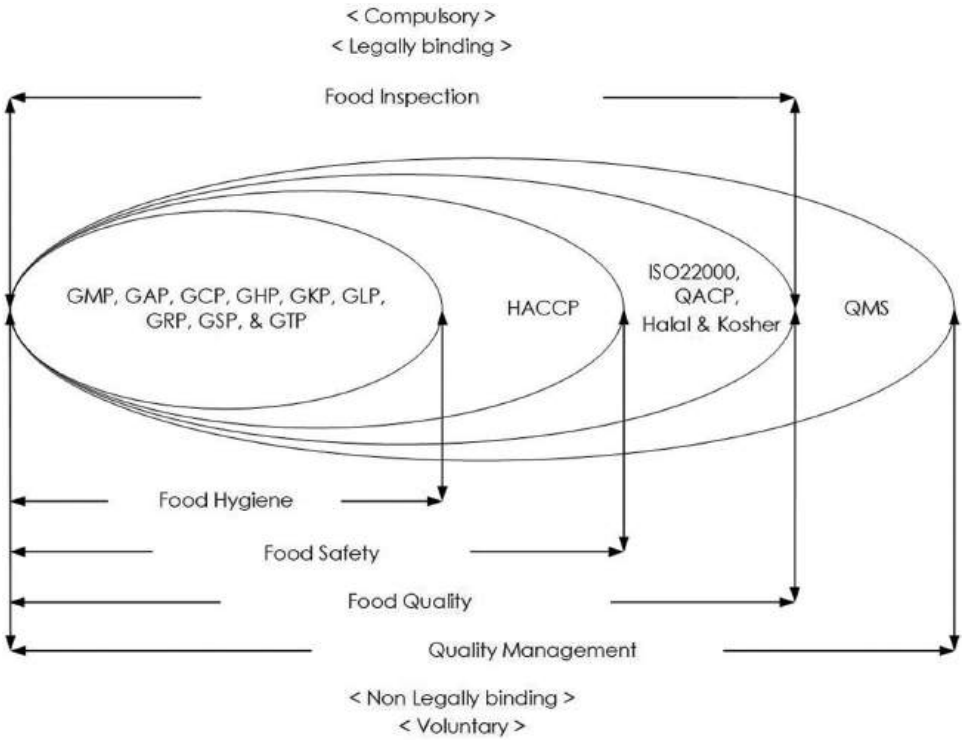

Figure 16. A diagrammatic representation of relationship between GMP, GAP, GHP, GCP, GKP, GLP, GRP, GSP and GTP, connecting with HACCP, QACP/Halal/Kosher and QMS, within the respective confines of food hygiene, safety, quality and QM (Source: Sikora & Strada [47] with modifications). GMP = Good Manufacturing Practice; GAP = Good Agricultural Practice; GHP = Good Hygiene Practice; GLP = Good Laboratory Practice; GRP = Good Retail Practice; GSP = Good Storage Practice; GTP = Good Transport Practice; HACCP = Hazard Analysis and Critical Control Points; QACP = Quality Assurance Control Points; QMS = Quality Management System; ISO = International Standard Organization

halal integrity[233] In the USA, food retailers especially the larger ones increasingly ensure that individual supplies enforce appropriate (good) practices to assure produce safety via GAPs, GMPs, and HACCP.[156] GCP guidelines could embrace a hybrid approach based on GMP guidelines combined with HACCP.[309] To advance the progress of the food quality system, both GMP and GHP would incorporate a prerequisite program (in traditional operations) that involves HACCP implementation.[97] HACCP is legally bound in the EU by Directive 93/43/EEC on the hygiene of foodstuffs. HACCP system is compulsorily applied in Poland by law on health conditions of food and nutrition – obligatory for medium/large food processing production plants. For small enterprises, GMP and GHP are applied.[101] Regardless of country, the implementation of HACCP fortifies the food safety in any given food establishment.

QM – a block of interrelated activities within the agro-food product industry that strongly connects food manufacturers with consumers.[240] Specifically, factors affecting product quality can include: a) customer requirements; b) product specifications, c) planning; d) purchasing and supplier assurance; e) purchased product/manufacturing process control; f) product control; g) inspection and testing; h) food safety management, and i) dispatch and distribution. When the above-mentioned (factors) are effectively organised to improve product quality, QM in the agro-food industry would increase control on product safety/quality given the changing consumer requirements, environmental concerns, increased competition as well as government interests.[240,310] QM standards when adopted bring about competitive advantages, which explain why some (agro-food) establishments prefer one standard type compared to another.[85] To implement any QM system, understanding the (quality) standard the product/service is certified with is key. To implement QM may come with its own

(peculiar/specific) challenges such as a) cost reduction; b) on-time delivery; c) top management lack of commitment; d) lack of qualified personnel; e) lack of raw materials; f) lack of employee training; g) inadequate teamwork; h) insufficient quality process documentation; as well as i) challenges regarding QM information interpretation.[219,311–313]

Within the agro-food industry, QM system targets to improve food product quality, as underpinned by such attributes as food safety, value, package, process, and nutrition. Some agro-food product industries would have some flexibility to implement quality standards particularly (external – based) quality certifications given the differences in hierarchical management levels.[17] A diagrammatic representation of the relationship between GMP, GAP, GHP, GCP, GKP, GLP, GRP, GSP, and GTP, connecting with HACCP, QACP/Halal/Kosher and QMS, within the respective confines of food hygiene, safety, quality, and QM, is displayed in Fig. 16. Both compulsory (legally binding) and voluntary (non-legally binding) aspects/constructs of the QM framework within (any given) agro-food industry can be seen. From Fig. 16, we also see the legally binding aspects of food hygiene, safety, and quality are seen to clearly interconnect. Therefore, when an agro-food unit/enterprise has been successfully implemented, in the likes of GCP, GHP, GMP, GAP, GKP – all of which do fall under/within the HACCP domains, the next target should be QM, which would utilise the quality standard and system that the industry has deemed as the most appropriate/suitable.[47] Specifically, kosher and halal, are equally safety standards in their own right, can be seen placed alongside the QACP. To reiterate, 'assurance' relates to product quality, and involves QA together with GHP, GMP, HACCP up to QACP, whereas 'management' relates to the establishment's/unit's overall layout/organisation with respect to product quality, which connects through quality management system (QMS) to ISO 9000, ISO 22000, etc.[47] It is to improve the food product quality that the integration of quality standards happened. For example, the ISO 22000 integrated both ISO 9001:2000 and HACCP system, which made the food quality and safety standards more effective.[43]

To implement QM production processes, there has to be an increased level of product quality robustly focused to ensure consumer satisfaction, which is among key facets that underpins the effective working of agro-food industry/sector with such programs as GMP, GHP, QACP, GAP, GCP, GKP (Good Kitchen Practice) and HACCP.[47,257] For instance, GMP requires that the agro-food industry must meet food safety requirements, which even to the food handlers must undertake GMP training and refresher courses for continued and effective assimilation of work philosophy.[218] Although GHP and GMP have similar scope, both follow the principle of 'write down how you do it, do as you have written it down'. Whereas QA/QM procedures depend exclusively on the agro-food unit, all hygiene-sanitary requirements have to comply with the existing national regulatory body.[43] In the QM context, HACCP systematically targets the implementation of food safety via the QA principle, which makes each food company, enterprise/production line to adapt its QACP unique.[47]

With the relevant literature synthesised thus far, we can see that the QM appears strategically situated with high promise to elevate food hygiene quality standards and its associated processes. This would corroborate with the researches of earlier quality experts/workers[306,310,314] that emphasised that QM practices contribute to the overall industry performance to secure competitive advantage. Essentially, it is not establishing the QM system within the agro-food product industry that really matters, the real deal is about maintaining and sustaining it. Maintaining the QM system requires planning, organisation, and establishment of a workable and viable routine. Oftentimes, the maintenance work can be either overlooked or postponed, and this is not profitable. Last-minute QM activities should, therefore, be avoided so as not to lose sight of the required corrective actions. Useful examples of QM maintenance can include: (a) management review; (b) internal quality audit; (c) document control; and (d) quality record-keeping.[240] In addition, if QM were to be based on ISO 9000 standard, it could cover such aspects as: (a) management of the organisation; (b) management of resources; (c) process of product realisation; (d) measurements; (e) analysis; and (f) improvement.[43] Strengthening and essentially, sustaining the QM within the agro-food industry signals its usefulness, despite being a non-obligatory (that is, voluntary) system, which someday would eventually become

the de facto requirement. From the above-mentioned, QM remains very promising to coordinate the implementation of food hygiene quality safety standards and its related processes.

Nonetheless, process control/standardisation, benchmarking/harmonisation, traceability, food inspection/legislations, risk assessment, validation/verification, and personnel assessment/training altogether cumulate the supplementary essentials that facilitate QM's progress within the agro-food products industry. Despite the sensitive nature of agro-food products and complexities of the supply chain, the QM has the potential to enhance consumer protection/safety notwithstanding the diverse elements that affect agro-food products, from pollution, industrial processes, variations in consumer preference, to the perishability of fresh foodstuffs. As such, QM's performance measurement system indicators appropriately reflect quality aspects of both products and processes.[269] Besides traceability systems to tackle the growing consumer food safety challenges/issues,[47] process standardisation of the agro-food product industry would connect with all the quality implementation levels, although each (implementation level) would have to be subject to some form of validation and verification.[37] Nonetheless, the effective production of safe/wholesome (agro)food products can be accomplished via hazard prevention and process improvement strategies. Through this, the HACCP verification emerges as a preventive-based mode of operation. If the HACCP plan is not valid, food product safety will not be completely assured. Oftentimes, validating the effectiveness of control measures employed in food production would require some level of microbiological competences as well as expertise.[288]

Concluding remarks

If QM is to work, moral values have to be developed and maintained, and this is essentially true to the agro-food product industry. Through food quality safety standards, food processors are obliged to ensure food products meet the required quality safety standards. Good practices, from GHP, GAP, GMP, GCP to GTP, all have a common objective if carried out effectively and efficiently, which is, to compulsorily ensure the high quality level of food product hygiene and consumer safety. Through the combined efforts of HACCP and QA control points (QACP) that targets to ensure improved food hygiene, both quality and safety levels can be further enhanced and sustained. This makes the agro-food product industry capable of achieving as well as reaching some desirable QM targets. When good practices are achieved with HACCP, the next target will be that of QM, which would have to utilise the quality standard/system that has been deemed as the most appropriate by the food enterprise/unit. Considering the complexities of the agro-food product supply chain, QM appears strategically situated to advance food hygiene quality standards and related processes. However, establishing the QM system within the agro-food product establishment/unit is not the real deal, it is about maintaining and sustaining it, which certainly requires consistency in planning, organisation, and establishment of a routine. As ISO promotes standardisation of processes, food industries can greatly benefit from ISO22000. In addition, Kosher and Halal are food quality safety standards in their respect as both are placed alongside QACP. Notably, process control/standardisation, benchmarking/harmonisation, traceability, food inspection/legislations, risk assessment, validation/verification, and personnel assessment/training are supplementary essentials useful in facilitating the functioning of QM in the agro-food product industry.

In addition, how (all) good practices discussed in this current work operate under Kosher and Halal quality standards are among research areas that requires additional investigations to supplement existing literature. Interestingly, with respect to Halal, a number of emerging researches have involved good practices, [315–317] which suggests that more studies should be encouraged, in order to build up the body of knowledge. Considering COVID-19 global pandemic that has spread across the continents,[318] and despite that there is no evidence of yet regards transmission through food, the real importance of food safety particularly good practices across all stages of the food supply chain cannot be overemphasised.[319] Because of the COVID-19 pandemic situation, and here in Poland as at the time of this current review, which is similar to many other countries' situation around the globe,

the food establishments/firms have had no option but to step-up their good (food hygiene quality safety) practices.

Future prospects

Consumers and food unit managers as well as owners across the globe would definitely perceive QM in different ways. Therefore, it would be useful to know how QM functions in food establishments through the standpoint of both consumers and food unit managers/owners, aiming to improve food quality standards and this could be the direction for a future research. In addition, how cleaner food production could be achieved through the action as well as implementation of (food) hygiene quality safety practices/standards and subsequently enhanced, starting from the retail to supermarket/food industrial levels could be another direction of future research. Given the challenges that confront QMS in the food industry, further research is required that would aim to further understand the problems/non-conformities that emanate during the auditing of (QMS) systems. Understanding the factors that bring about such problems/non-conformities during the auditing process of QMS (and FSMS) would be useful to delineate.

The cost of adopting and subsequently implementing ISO standards is understood to scare away the small-scale food industries around the globe. It would be useful for future studies to seek for a low-cost approach that would help ascertain the quality of agro-food products, based on the compulsory QM aspects, which would involve good practices, food hygiene, quality and safety. This could be in the form of a questions-based framework, which would at the same time, target the quality aspects of the food technological processes especially those of small-scale food industries, who are unable to afford to implement these QM-based ISO standards. Such questions-based framework could help lay a foundation of understanding which QM approach would be more applicable. It could also help make more key aspects of QM to become a reality specific to the small-scale food industries. Besides, there is need for additional literature synthesis/studies to help establish how food safety knowledge contributes to serving as a robust quality tool for FSMS, especially from the QM standpoint. Besides the implementation of ISO standards, it would be useful for future studies to compare ISO certifications and their locations/sites across the continents and food sectors, as it might provide a clue regards the extent QM has progressed across various countries.

Another area not covered in this review that needs attention is deducing the novelties that might be existing in the latest ISO9001:2015, applicable to the food industry/sector. In this direction, future reviews should look at the context of management principles, and risk-based approaches. Another area that has not been captured in this current review is total quality management (TQM) as it pertains to the agro-food industry. Thus, a robust literature synthesis is warranted, particularly to examine how TQM tools are applicable and relevant for (food) product development, and how such could bring about improvement from small-medium to large-scale production. There is also need for robust analysis of ISO 9001 and 22000 certificates and sites within the global agro-food sector to ascertain the current status, trend across countries, and degree of association with respect to certificates/sites versus countries. This could be performed in the form of data mining/visualisation, and with respect to expanding the body of knowledge, the use of systematic review, and or meta-analysis becomes very useful.. All emergent data from the above-mentioned future researches would surely help to supplement existing information.

Acknowledgments

Thanks to Dott. Giacomo Sardo (IRBIM CNR, Mazara del Vallo, Italy) for his help with Figs. 11 and Figs.16.

Funding

Funding by Wrocław University of Environmental and Life Sciences (Wrocław, Poland) to COR Okpala and M Korzeniowska is gratefully acknowledged.

ORCID

Charles Odilichukwu R. Okpala http://orcid.org/0000-0003-4475-8887
Małgorzata Korzeniowska http://orcid.org/0000-0002-0300-0407

Author contributions

COR Okpala conceptualised the idea, collected the data, compiled and wrote the manuscript. M Korzeniowska contributed to, and corrected the manuscript. All the involved authors contributed to the scientific content and approved the final submitted manuscript.

Conflicts of interest

The authors declare no conflict of interest related to the contents of this manuscript.

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