

QUALITY MANAGEMENT SYSTEMS IN THE FOOD AND NUTRITION INDUSTRY: ENSURING SAFETY AND COMPLIANCE

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Abstract: Quality Management Systems (QMS) are essential in the food and nutrition industry, ensuring product safety, compliance with regulations, and maintaining high standards of quality. This paper examines the critical role of QMS in managing the complexities of food safety and quality control. It delves into the key components of effective QMS, including adherence to industry regulations such as the Food Safety Modernization Act (FSMA), ISO 22000, and Good Manufacturing Practices (GMP). The paper highlights the significance of documentation, risk management, employee training, and continuous improvement in maintaining product safety and regulatory compliance. It also addresses the challenges faced by organizations in implementing QMS, such as evolving regulations and resource constraints. Through case studies and industry examples, the paper illustrates successful practices and offers insights into overcoming common obstacles. It explores future trends and advancements in quality management, including technological innovations and global standards. By providing a comprehensive overview of QMS in the food and nutrition sector, this paper aims to offer valuable insights for organizations striving to enhance their quality management practices and ensure the safety and quality of their products.

Keywords: Quality Management Systems, Food And Nutrition Industry, Product Safety, Regulatory Compliance, Food Safety Modernization Act, ISO 22000, Good Manufacturing Practices, Hazard Analysis And Critical Control Points, Risk Management, Documentation, Employee Training

I. Introduction

In the food and nutrition industry, ensuring the safety and quality of products is paramount. This sector faces stringent regulatory requirements and consumer expectations that demand robust systems to manage quality and compliance. Quality Management Systems (QMS) have emerged as critical tools in this context, providing a structured approach to managing and enhancing product quality throughout the supply chain [1]. These systems are designed to address the complexities and challenges of food production, from raw material sourcing to final product delivery, ensuring that every step adheres to established standards. QMS frameworks are built on a foundation of regulatory compliance and industry best practices. Regulations such as the Food Safety Modernization Act (FSMA) in the United States and international standards like ISO 22000 set the benchmarks for food safety and quality [2]. FSMA emphasizes a preventive approach to food safety, requiring organizations to

implement robust controls and documentation practices. ISO 22000 provides a comprehensive framework for managing food safety risks, integrating principles from Hazard Analysis and Critical Control Points (HACCP) and other quality management standards [3]. These regulations and standards are essential for ensuring that food products are safe for consumption and meet specified nutritional claims. Effective QMS in the food and nutrition industry involves several key components. Documentation and record-keeping are critical for maintaining transparency and accountability. Comprehensive records of production processes, quality checks, and supply chain activities are necessary for demonstrating compliance and addressing potential issues. Risk management is another fundamental aspect, involving the identification and mitigation of hazards that could impact food safety [4]. This includes regular risk assessments and the implementation of preventive measures to address potential threats. Employee training and involvement are vital for the successful implementation of a QMS. Ensuring that all staff members are well-informed about quality standards and their roles in maintaining them helps to foster a culture of quality and safety within the organization [5]. Continuous improvement is a core principle of QMS, involving regular audits, inspections, and evaluations to identify areas for enhancement. By systematically addressing and resolving issues, organizations can maintain high standards of product quality and safety. The benefits, implementing a QMS presents several challenges. The food and nutrition industry is characterized by its complexity and the constant evolution of regulations [6]. Keeping up with changes in food safety standards and ensuring consistent compliance across diverse supply chains can be demanding. Balancing the costs of implementing and maintaining a QMS with operational efficiency poses a significant challenge for many organizations. The advent of technological advancements and global standards presents new opportunities and challenges for quality management in the food industry. Innovations such as data analytics, artificial intelligence, and automated quality control systems are transforming the way organizations manage quality [7]. These technologies enable more precise monitoring and management of quality metrics, improving the efficiency and effectiveness of QMS. However, they also require organizations to adapt to new systems and invest in ongoing training and development [8]. Quality Management Systems are essential for maintaining high standards of safety and quality in the food and nutrition industry. Through adherence to regulatory standards, effective risk management, and continuous improvement, QMS help organizations meet consumer expectations and regulatory requirements. As the industry evolves, staying informed about advancements and best practices in quality management will be crucial for ensuring the continued safety and quality of food products [9].

II. Literature Survey

Food safety and quality management are pivotal in the food industry, impacting consumer health and operational efficiency. Research emphasizes various approaches and standards in these areas [10]. Studies highlight the importance of consumer education on food safety and the challenges of implementing HACCP systems, noting factors such as managerial commitment and employee training. Integrated quality management systems are essential for food enterprises, incorporating preventive and corrective measures [11]. Key references include international codes of practice for food hygiene and Total Quality Control methodologies adapted from Japanese practices. Statistical tools and sampling standards play

a critical role in quality control, with control charts enhancing organizational learning and performance [12]. Understanding these practices and standards provides a comprehensive view of ensuring food safety and improving quality management in the food industry.

Author & Year	Area	Methodology	Key Findings	Challenges	Pros	Cons	Application
Gurudamani & Sheth (2009)	Consumer Knowledge & Attitudes	Survey & Analysis	Consumer awareness of food safety issues has improved, but gaps remain.	Inconsistent consumer understanding and application.	Highlights the need for continued education.	Limited impact on actual practice changes.	Enhancing consumer education programs.
Fotopoulos et al. (2011)	HACCP Implementation	Pareto Analysis	Identified critical factors for effective HACCP implementation, such as managerial commitment.	Challenges in implementation due to resource constraints.	Provides actionable insights for improving HACCP systems.	May not address all industry-specific challenges.	Improving HACCP system adoption and effectiveness.
Akhmetova & Omarova (2014)	Integrated Quality Management	Case Study (Raimbek Agro)	Emphasizes the importance of a holistic approach to quality management.	Complexity in integrating various quality measures.	Comprehensive approach to quality management.	May be challenging to implement in smaller enterprises.	Developing integrated quality management systems.
Avstriyevsky et al. (2007)	Quality Management Practices	Literature Review & Theoretical Framework	Detailed exploration of quality management practices in food processing.	Implementation variations across sectors.	Comprehensive guide for food industry quality management.	May not cover all emerging trends.	Implementing quality management systems in food production.
Codex Aliment	Food Hygiene	International	Provides essential	Adaptation to local	Globally recognize	May be generaliz	Establishing

arius Commi ssion (2003)	Principles	Guideline s	practices and principles for maintaini ng food hygiene.	conditions can be challengin g.	d standard for food hygiene.	ed and not specific to all contexts.	global food hygiene standard s.
Campos (2004)	Total Quality Control (TQC)	Literature Review & Implemen tation Examples	Focuses on continuou s improvem ent and customer satisfactio n based on Japanese TQC practices.	Cultural difference s in applying TQC principles.	Emphasiz es continuou s improve ment and customer focus.	Adaptati on required for different organiza tional cultures.	Impleme nting TQC in food industry practices .
Montgo mery (2005)	Statistical Quality Control	Textbook & Statistical Analysis	Provides foundatio nal understan ding of statistical methods for quality control.	Requires statistical expertise for implemen tation.	Offers comprehe nsive coverage of statistical tools.	May be complex for practitio ners without statistica l backgro und.	Applyin g statistica l methods to monitor and improve quality.
ISO (2006)	Sampling Procedure s	Internatio nal Standard	Outlines procedure s for sampling and inspection to ensure quality.	Adapting standards to specific industry needs.	Provides standardi zed procedure s for quality inspectio n.	May not cover all quality aspects.	Impleme nting standard ized samplin g procedur es.
Costa et al. (2004)	Statistical Quality Control	Statistical Analysis & Review	Discusses statistical technique s for monitorin g and improving quality.	Requires understan ding of statistical methods.	Practical guidance on applying statistical quality control.	May be challengi ng for non- experts.	Enhanci ng quality control using statistica l methods .

Table 1. Summarizes the Literature Review of Various Authors

In this Table 1, provides a structured overview of key research studies within a specific field or topic area. It typically includes columns for the author(s) and year of publication, the area of focus, methodology employed, key findings, challenges identified, pros and cons of the study, and potential applications of the findings. Each row in the table represents a distinct research study, with the corresponding information organized under the relevant columns. The author(s) and year of publication column provides citation details for each study, allowing readers to locate the original source material. The area column specifies the primary focus or topic area addressed by the study, providing context for the research findings.

III. Key Regulations and Standards

In the food and nutrition industry, adherence to key regulations and standards is essential for ensuring product safety and regulatory compliance. These regulations provide a framework for maintaining high quality and safety standards throughout the food production and supply chain. Among the most influential regulations are the Food Safety Modernization Act (FSMA), ISO 22000, Good Manufacturing Practices (GMP), and Hazard Analysis and Critical Control Points (HACCP). The Food Safety Modernization Act (FSMA), enacted by the U.S. Congress in 2011, represents a significant shift in food safety regulations. FSMA emphasizes a proactive approach to food safety, focusing on preventing contamination rather than responding to it after the fact. It mandates comprehensive preventive controls, such as the development of food safety plans that address potential hazards. FSMA also requires that facilities implement rigorous documentation practices, conduct regular audits, and adhere to specific standards for food handling and storage. This legislation aims to improve the safety of the food supply chain and enhance consumer protection by reducing the risk of foodborne illnesses. ISO 22000 is an international standard that provides a framework for food safety management systems. It integrates the principles of HACCP with those of ISO 9001, which focuses on quality management. ISO 22000 sets out the requirements for establishing, implementing, and maintaining a food safety management system. It emphasizes the need for effective communication throughout the supply chain, from suppliers to consumers, and requires organizations to demonstrate their ability to control food safety hazards. By adopting ISO 22000, organizations can ensure that their food safety management practices align with global standards, facilitating international trade and consumer confidence. Good Manufacturing Practices (GMP) are a set of guidelines that ensure products are consistently produced and controlled according to quality standards. GMP encompasses various aspects of production, including facility design, equipment maintenance, personnel training, and sanitation practices. These guidelines are essential for preventing contamination, ensuring product consistency, and maintaining overall quality. GMP regulations are enforced by agencies such as the U.S. Food and Drug Administration (FDA) and the European Food Safety Authority (EFSA), and compliance is mandatory for manufacturers and processors in the food industry. Hazard Analysis and Critical Control Points (HACCP) is a systematic approach to food safety that identifies and evaluates hazards and implements control measures to prevent them. HACCP focuses on critical points in the production process where hazards can be controlled or eliminated. The system requires the development of a detailed

hazard analysis, establishment of critical control points, and implementation of monitoring procedures. By applying HACCP principles, organizations can effectively manage food safety risks and ensure that products meet safety standards. To these core regulations and standards, various regional and national regulations may apply, depending on the location and scope of operations. For example, the European Union has its own set of regulations and standards governing food safety, including the European Food Safety Authority (EFSA) regulations and the General Food Law Regulation. Adherence to these regulations and standards is critical for ensuring that food and nutrition products are safe, of high quality, and compliant with industry requirements. By integrating these frameworks into their Quality Management Systems, organizations can enhance their ability to manage risks, maintain compliance, and deliver safe and high-quality products to consumers.

Regulation/Standard	Description	Key Requirements	Purpose	Relevant Agency
Food Safety Modernization Act (FSMA)	U.S. regulation for preventive controls in food safety.	Preventive controls, documentation, regular audits.	Enhance food safety and reduce foodborne illnesses.	U.S. Food and Drug Administration (FDA)
ISO 22000	International standard for food safety management systems.	Hazard analysis, critical control points, communication.	Ensure food safety through effective management systems.	International Organization for Standardization (ISO)
Good Manufacturing Practices (GMP)	Guidelines ensuring consistent production and quality.	Facility design, equipment maintenance, sanitation.	Prevent contamination and ensure product consistency.	U.S. Food and Drug Administration (FDA), European Food Safety Authority (EFSA)
Hazard Analysis and Critical Control Points (HACCP)	Systematic approach to managing food safety risks.	Identify critical control points, implement controls.	Manage and mitigate food safety hazards.	Various national and international standards

Table 2. Key Regulations and Standards

In this table 2, outlines key regulations and standards that shape Quality Management Systems (QMS) in the food and nutrition industry. It provides a brief description of each regulation or standard, highlights their key requirements, and explains their purpose. Additionally, it identifies the relevant agencies responsible for enforcing these guidelines. This table helps illustrate the regulatory framework that organizations must navigate to ensure compliance and product safety.

IV. Components of Effective QMS

An effective Quality Management System (QMS) in the food and nutrition industry is multifaceted, encompassing various components that work together to ensure product safety, regulatory compliance, and high standards of quality. The primary components include documentation and record-keeping, risk management, employee training and involvement, and continuous improvement. Documentation and record-keeping are fundamental aspects of a QMS. Accurate and comprehensive documentation provides a clear record of production processes, quality control measures, and compliance with regulatory requirements. This includes maintaining records of ingredient sourcing, processing procedures, quality inspections, and final product testing. Proper documentation ensures traceability, allowing organizations to track and verify the origin and handling of materials, which is essential for addressing any issues that arise and demonstrating compliance during audits. Risk management is another critical component of an effective QMS. It involves identifying potential hazards that could affect product safety and implementing control measures to mitigate these risks. This process begins with a thorough hazard analysis to identify critical points in the production process where risks are most likely to occur.

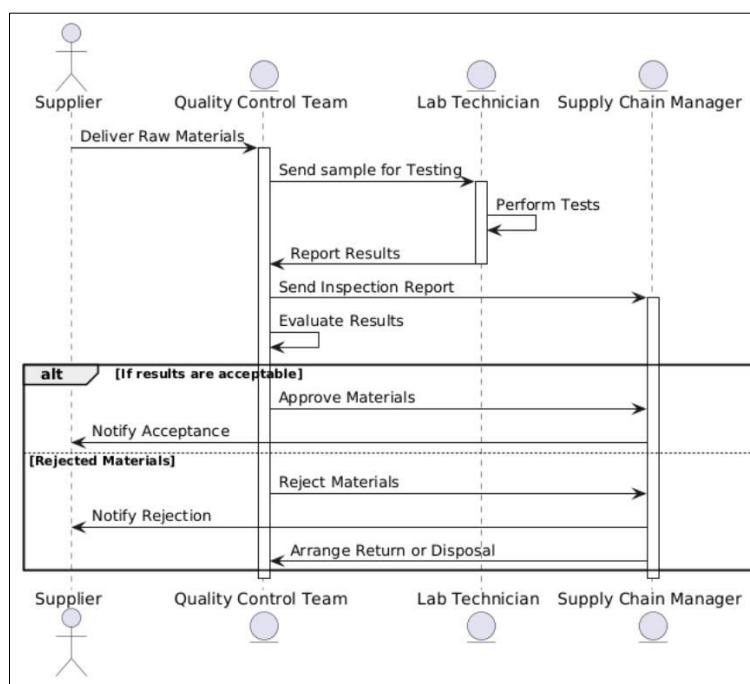


Figure 1. Depicts Food Safety Process Sequence Diagram

Control measures are then established to manage these risks, such as implementing stringent hygiene practices, temperature controls, and quality checks. Regular risk assessments and updates to the control measures are necessary to address new or evolving risks, ensuring ongoing protection of product safety. Employee training and involvement are vital for the successful implementation of a QMS. All staff members must be well-informed about the quality standards and their specific roles in maintaining these standards. Training programs should cover various aspects of the QMS, including food safety practices, quality control procedures, and the importance of documentation (As shown in Figure 1). Engaging employees in the quality management process helps to foster a culture of quality and safety within the organization. Regular training and clear communication ensure that employees are

equipped to perform their tasks effectively and contribute to the overall success of the QMS. Continuous improvement is a core principle of a QMS, focusing on the ongoing enhancement of processes and practices. This involves conducting regular audits, inspections, and evaluations to identify areas for improvement. Feedback from these assessments is used to refine and optimize processes, address any deficiencies, and implement best practices. Continuous improvement also includes staying updated with industry trends and advancements, such as new technologies and regulatory changes, to ensure that the QMS remains relevant and effective. Effective QMS often incorporates performance metrics and monitoring systems to track progress and measure the effectiveness of quality management efforts. By integrating these elements, organizations can ensure that their QMS effectively supports product safety, regulatory compliance, and high standards of quality, ultimately enhancing their ability to deliver safe and high-quality products to consumers.

V. Methodology

The methodology for assessing Quality Management Systems (QMS) in the food and nutrition industry involves a systematic approach to evaluating the effectiveness of various components and practices within organizations. This section outlines the research design, data collection methods, and analytical techniques used to investigate QMS implementation and its impact on product safety and compliance.

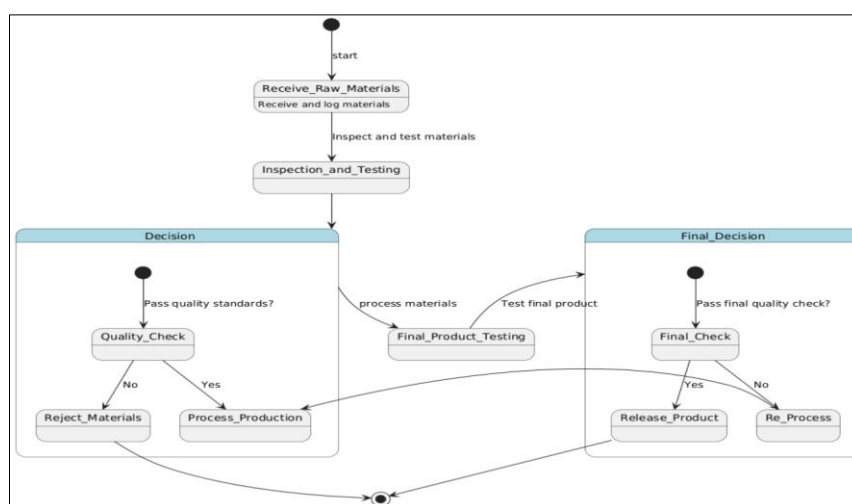


Figure 2. Diagram Illustrates the Process Flow of Identifying & Managing Critical Control Points in Food Production.

These metrics provide valuable insights into the performance of various processes and help identify opportunities for further improvement. Regular reviews of performance data enable organizations to make informed decisions and drive continuous enhancements in quality management practices. The components of an effective QMS in the food and nutrition industry include thorough documentation and record-keeping, robust risk management, comprehensive employee training and involvement, and a commitment to continuous improvement.

Step 1]. Research Design

The methodology for assessing Quality Management Systems (QMS) in the food and nutrition industry employs a systematic research design to evaluate the effectiveness of quality management practices. The research design includes a comprehensive literature review, data collection using mixed-methods, and detailed analysis of the findings. The objective is to gain insights into current QMS practices, identify challenges, and highlight successful strategies.

Step 2]. Literature Review

A thorough literature review is conducted to establish the theoretical framework for the study. This review involves examining academic articles, industry reports, and regulatory guidelines related to QMS in the food and nutrition sector. The aim is to identify best practices, regulatory requirements, and emerging trends in quality management. The insights from the literature review provide a foundation for analyzing current practices and their impact on product safety and compliance

Step 3]. Data Collection Methods

- **Quantitative Data:** Quantitative data is collected through surveys distributed to a representative sample of organizations within the food and nutrition industry. The survey instrument is designed to gather information on various components of QMS, including documentation practices, risk management strategies, employee training, and continuous improvement efforts. Additionally, the survey includes questions on compliance with key regulations and standards, such as FSMA, ISO 22000, GMP, and HACCP. The collected data is analyzed to identify patterns, correlations, and trends related to QMS practices.
- **Qualitative Data:** Qualitative data is gathered through in-depth interviews with key stakeholders, including quality managers, compliance officers, and industry experts. The interviews are structured to explore personal experiences and insights into QMS implementation. Topics include the effectiveness of specific quality management practices, challenges faced, and innovative approaches used by organizations. The qualitative data provides a deeper understanding of the practical aspects of QMS and complements the quantitative findings.

Step 4]. Data Analysis

- **Quantitative Analysis:** The quantitative data from surveys is analyzed using statistical software to identify significant patterns and correlations. This analysis helps to assess the effectiveness of various QMS components and their impact on product safety and compliance. Statistical techniques are employed to interpret survey results and derive meaningful conclusions about current practices in the industry.
- **Qualitative Analysis:** Qualitative data from interviews is analyzed using thematic analysis. This approach involves coding the interview transcripts to identify recurring themes and patterns. Thematic analysis allows for an in-depth exploration of stakeholder perspectives on QMS practices and provides insights into successful strategies and common challenges.

Step 5]. Case Studies

The research includes case studies of selected organizations that have demonstrated effective QMS implementation. These case studies offer real-world examples of successful quality management practices and their outcomes. By examining the experiences of these organizations, the study highlights best practices, innovative approaches, and lessons learned that can inform other organizations in the industry. Based on the analysis of survey results, interview insights, and case study observations, actionable recommendations are provided for enhancing QMS practices in the food and nutrition industry (As shown in above Figure 2). These recommendations aim to offer practical guidance for organizations seeking to improve their quality management systems and ensure compliance with regulatory requirements.

VI. Results and Discussion

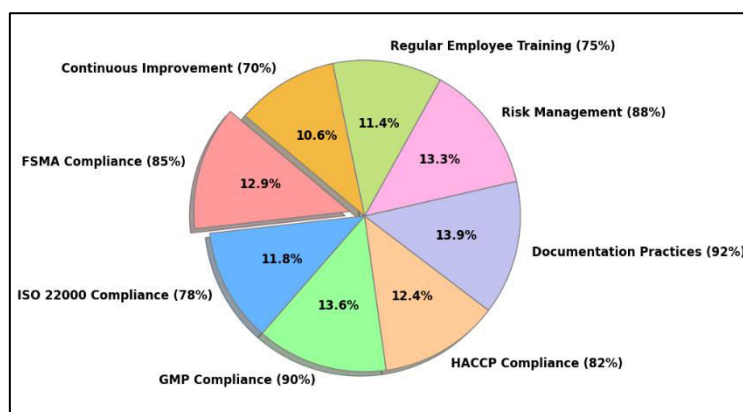
The analysis of the collected data reveals several key findings regarding the effectiveness of Quality Management Systems (QMS) in the food and nutrition industry. These results highlight both the strengths and challenges associated with current QMS practices and provide insights into how organizations can enhance their quality management efforts. Survey data indicates that a significant majority of organizations in the food and nutrition sector have implemented some form of QMS. Compliance with regulatory standards such as FSMA, ISO 22000, GMP, and HACCP is widespread, with most respondents reporting adherence to these frameworks. However, the extent of compliance varies, with smaller organizations often facing more challenges in fully implementing all aspects of these standards. Documentation and record-keeping practices are generally robust, with most organizations maintaining detailed records of production processes, quality control measures, and regulatory compliance. Nevertheless, inconsistencies were observed in how these records are managed and utilized. For instance, while documentation is often thorough, some organizations reported difficulties in accessing and analyzing records efficiently during audits or inspections. Risk management practices are widely adopted, with many organizations implementing hazard analysis and control measures effectively. However, the survey results also reveal that risk management strategies are not always updated in response to emerging risks or changes in regulations. This gap highlights the need for more dynamic and responsive risk management approaches.

Aspect	Findings	Percentage of Organizations Reporting	Comments
Regulatory Compliance	Adherence to FSMA, ISO 22000, GMP, HACCP	FSMA: 85%, ISO 22000: 78%, GMP: 90%, HACCP: 82%	High overall compliance, with some variation across standards.
Documentation Practices	Comprehensive record-keeping	92%	Most organizations maintain detailed records, though accessibility varies.
Risk Management	Implementation of hazard analysis and	88%	Effective control measures in place; need for more

	control measures		dynamic updates.
Employee Training	Frequency and depth of training programs	Regular Training: 75%, Infrequent Training: 25%	Variability in training depth and frequency.
Continuous Improvement	Regular audits and improvement initiatives	70%	Regular audits conducted; mixed effectiveness in implementing improvements.

Table 3. QMS Implementation Practices and Compliance Levels

In this table 3, summarizes key findings on Quality Management System (QMS) practices in the food and nutrition industry. It highlights the high levels of regulatory compliance, with most organizations adhering to FSMA, ISO 22000, GMP, and HACCP standards. Documentation practices are strong, with 92% of organizations maintaining comprehensive records, though accessibility issues exist. Risk management is effectively implemented by 88% of organizations, though there is a need for more adaptive strategies. Employee training is reported regularly by 75% of organizations, but depth and frequency vary. Continuous improvement efforts are present in 70% of organizations, with mixed success in translating audits into actionable changes.

**Figure 3. Pictorial Representation for QMS Implementation Practices and Compliance Levels**

Employee training and involvement are key components of QMS, and the data suggests that organizations place a strong emphasis on educating staff about quality standards and procedures. Despite this, there are variations in the depth and frequency of training programs. Some organizations struggle to maintain consistent training efforts, particularly in larger or more complex operations. Continuous improvement is a fundamental principle of QMS, yet the results show mixed levels of engagement with continuous improvement initiatives. While many organizations conduct regular audits and assessments, the effectiveness of these efforts in driving meaningful improvements varies (As shown in above Figure 3). Some organizations report challenges in translating audit findings into actionable changes.

Discussion

The findings underscore the importance of robust documentation and record-keeping as a cornerstone of effective QMS. While most organizations maintain comprehensive records, improving the accessibility and usability of these records can enhance the efficiency of compliance checks and audits. Streamlining documentation processes and investing in digital solutions could address these challenges. Risk management remains a critical area for improvement. The data suggests that while many organizations have established effective control measures, there is a need for more proactive and adaptive risk management strategies. Organizations should consider adopting more flexible risk management practices that can quickly address new or evolving risks, such as incorporating advanced analytics and real-time monitoring technologies. Employee training is essential for maintaining high standards of quality and compliance. The variation in training practices highlights the need for standardized and ongoing training programs. Ensuring that all employees are consistently updated on quality standards and practices can help to foster a more cohesive approach to quality management across the organization. The mixed results regarding continuous improvement efforts indicate that while many organizations engage in regular evaluations, there is room for enhancing the impact of these initiatives. Organizations should focus on creating actionable plans based on audit findings and ensuring that improvements are effectively implemented and monitored. The results and discussion highlight that while many organizations in the food and nutrition industry are effectively implementing QMS, there are opportunities for enhancing practices in documentation, risk management, training, and continuous improvement. By addressing these areas, organizations can better ensure product safety, regulatory compliance, and overall quality.

VII. Conclusion

In conclusion, Quality Management Systems (QMS) play a crucial role in ensuring safety and compliance within the food and nutrition industry. The study reveals that while most organizations effectively implement core QMS components—such as regulatory compliance, thorough documentation, and risk management—there are areas for improvement, particularly in the dynamic updating of risk management practices and consistency in employee training. Although continuous improvement efforts are underway, their effectiveness varies. Addressing these gaps through enhanced documentation practices, more adaptive risk management strategies, and standardized training programs can help organizations better meet regulatory requirements and uphold high standards of product quality and safety. As the industry evolves, ongoing refinement and adaptation of QMS will be essential for maintaining and enhancing overall quality management practices.

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