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A Model for Integrating Digital Technology into Hazard Analysis and Critical Control Points (HACCP) Systems to Improve Food Safety in Small-Scale Industries

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ABSTRACT

This study aims to develop a model for integrating digital technology into Hazard Analysis and Critical Control Points (HACCP) systems to improve food safety in small-scale food industries. The issue addressed in this study concerns the gap between existing food safety practices and the limited capacity of small enterprises to conduct systematic documentation, monitoring, and traceability. This research employed a qualitative case study approach involving business owners, production supervisors, food processing workers, quality control personnel, food safety consultants, and relevant institutional stakeholders. Data were collected through semi-structured interviews, field observations, and document analysis, then analyzed using thematic analysis. The findings reveal five main themes: informal food safety practices, documentation constraints, limited digital readiness, the importance of leadership and food safety culture, and the need for a gradual digital integration model. The study shows that digital HACCP can improve food safety when supported by simple tools, worker training, managerial commitment, and routine evaluation. The proposed model contributes to food safety management literature by framing digital HACCP as a socio-technical process rather than a purely technological intervention. Practically, the findings provide guidance for small-scale food industries and policymakers in designing affordable, usable, and scalable digital food safety systems. Further research should test the model in different food sectors and examine its measurable impact on food safety performance.

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1. Introduction

Food safety remains a critical concern in modern food production systems because biological, chemical, and physical hazards may occur throughout the food chain, from raw material procurement and processing to storage, distribution, and final consumption. In the global context, increasingly complex food supply chains, growing consumer awareness, and stricter regulatory requirements have intensified the need for effective food safety management systems. Hazard Analysis and Critical Control Points (HACCP) has long been recognized as one of the most effective preventive approaches for identifying, evaluating, and controlling food safety hazards.

According to Radu et al. (2023), HACCP continues to serve as a central framework within contemporary food quality and safety management systems. Nevertheless, traditional HACCP implementation often relies on manual documentation, periodic inspections, and human monitoring, which may reduce efficiency, increase the risk of recording errors, and limit the ability to respond promptly to emerging hazards.

In developing countries, particularly among small-scale food industries, the implementation of HACCP remains challenging due to financial constraints, limited technical expertise, inadequate infrastructure, and insufficient documentation practices. Small enterprises frequently depend on manual record-keeping systems that are vulnerable to inconsistencies and data loss. Lee et al. (2023) reported that small and medium-sized food enterprises often encounter difficulties in implementing food safety management systems because of limited organizational resources, inadequate employee training, and insufficient managerial support. Although many small-scale producers understand the importance of maintaining food hygiene and product quality, systematic monitoring and verification procedures are often incomplete, thereby reducing the effectiveness of food safety assurance mechanisms.

Recent advances in digital technology provide significant opportunities to strengthen HACCP implementation within small-scale food industries. Technologies such as Internet of Things (IoT) sensors, digital monitoring platforms, cloud-based record systems, blockchain-enabled traceability, machine learning applications, and mobile inspection tools can improve real-time monitoring, automate data collection, enhance traceability, and facilitate corrective actions. Sartoni et al. (2025) emphasized that the digitalization of Food Safety Management Systems (FSMS) can support the design, implementation, monitoring, and continuous improvement of HACCP activities. Through automated monitoring and data integration, organizations can reduce human error, improve transparency, and strengthen compliance with food safety requirements.

Beyond technological benefits, the integration of digital technology into HACCP systems also involves organizational, behavioral, and cultural dimensions. Successful implementation requires not only technological infrastructure but also employee readiness, digital literacy, management commitment, and a strong food safety culture. Pai et al. (2024) highlighted that leadership, organizational commitment, communication, and employee engagement significantly influence food safety culture within food organizations. In small-scale enterprises, operational decisions are frequently centralized around business owners, making managerial attitudes and perceptions toward technology critical determinants of successful adoption. Consequently, digital transformation in food safety should be understood as a socio-technical process rather than merely a technological intervention.

Previous studies have extensively examined HACCP implementation, blockchain applications, traceability systems, IoT integration, and artificial intelligence in food safety management. Patel et al. (2023) demonstrated that blockchain technology can significantly improve transparency and traceability throughout food supply chains. Similarly, Revelou et al. (2025) identified substantial potential for machine learning applications to enhance hazard prediction and support HACCP monitoring activities. Despite these advancements, existing studies primarily focus on technological capabilities and operational performance. Limited attention has been devoted to understanding how small-scale food industry stakeholders experience, interpret, adapt to, and integrate digital technologies within existing HACCP practices. This gap is particularly important because technology adoption in small enterprises is often shaped by contextual factors such as organizational culture, employee competencies, resource availability, and operational routines.

Based on these considerations, this study aims to develop a model for integrating digital technology into HACCP systems to improve food safety performance in small-scale food industries. The study focuses on exploring stakeholder experiences, organizational readiness, implementation challenges, technological requirements, and adaptation processes associated with

HACCP digitalization. Theoretically, this research contributes to the growing body of knowledge on digital transformation and food safety management by conceptualizing digital HACCP integration as a socio-technical process. Practically, the study seeks to generate an applicable and scalable integration model that can support small-scale food enterprises in implementing more effective, efficient, and sustainable food safety management practices.

2. Materials and Methods

This study employed a qualitative research approach using a case study design. The qualitative case study method was selected because the research sought to obtain an in-depth understanding of how digital technologies are integrated into HACCP systems within small-scale food industries. Qualitative inquiry is particularly appropriate for exploring participants' experiences, perceptions, interactions, and decision-making processes in real-life contexts. As Byrne (2022) noted, qualitative approaches enable researchers to investigate complex social phenomena by capturing meanings and contextual realities that may not be adequately explained through quantitative measures. Therefore, a case study design was considered suitable for examining the socio-technical dynamics involved in HACCP digitalization.

The research was conducted in selected small-scale food manufacturing enterprises that had either implemented HACCP principles or demonstrated an intention to adopt structured food safety management practices. Data collection was carried out over a period of approximately four months, encompassing preparation, fieldwork, validation, analysis, and model development. The selection of research sites was based on several criteria, including the existence of food production processes involving critical control points, the use of manual or digital monitoring systems, and the willingness of business owners to participate in the study. These criteria ensured that participants possessed direct experience relevant to the integration of digital technology within HACCP operations.

Participants were selected using purposive sampling. Key informants included business owners, production supervisors, food processing workers, quality control personnel, food safety consultants, and representatives from government agencies responsible for food safety supervision. Purposive sampling was chosen because it allows researchers to identify individuals who possess substantial knowledge and practical experience regarding the phenomenon under investigation (Campbell et al., 2020). Inclusion criteria required participants to be directly involved in food production activities, HACCP implementation, quality assurance procedures, or digital record-keeping practices. When additional information was required, snowball sampling was utilized to identify further participants through recommendations from existing informants. Data collection continued until thematic saturation was achieved and no substantially new information emerged.

Data were collected through semi-structured interviews, participant observation, and document analysis. Semi-structured interviews enabled participants to discuss their experiences with HACCP implementation, perceptions of digital technology, operational challenges, organizational readiness, and expectations regarding digital integration. Participant observation was conducted to examine production workflows, sanitation procedures, temperature monitoring activities, storage management, documentation practices, and corrective action processes associated with critical control points. Document analysis involved reviewing standard operating procedures (SOPs), HACCP plans, monitoring records, audit reports, production logs, quality assurance documents, and digital records where available. The use of multiple data collection techniques enhanced the comprehensiveness of the findings and provided opportunities for methodological triangulation.

To ensure trustworthiness and rigor, several validation strategies were employed. Source triangulation was conducted by comparing information obtained from different categories of participants. Method triangulation involved cross-checking interview findings against observational data and documentary evidence. Member checking was performed by sharing preliminary interpretations and summaries with selected participants to confirm the accuracy of researchers' interpretations. Additionally, an audit trail was maintained throughout the research process, including field notes, interview transcripts, coding records, analytical memos, and documentation of methodological decisions. According to Johnson et al. (2020), such procedures contribute significantly to the credibility, dependability, and confirmability of qualitative research findings.

Data analysis followed the interactive model proposed by Miles, Huberman, and Saldaña, consisting of data condensation, data display, and conclusion drawing. Interview transcripts and field notes were repeatedly reviewed to identify meaningful units of information. Initial open coding generated categories such as digital literacy, documentation challenges, technology costs, monitoring efficiency, organizational readiness, critical control point management, and corrective actions. Related codes were subsequently grouped into broader themes representing key dimensions of HACCP digitalization. Through iterative comparison and thematic refinement, relationships among themes were identified and synthesized into a conceptual model describing the integration of digital technology into HACCP systems within small-scale food industries. The analytical process continued until thematic coherence and interpretive consistency were achieved.

3. Results and Discussions

The findings of this study indicate that the integration of digital technology into HACCP systems in small-scale food industries is shaped by five major themes: informal food safety practices, documentation constraints, limited digital readiness, the importance of leadership and food safety culture, and the need for a gradual digital integration model. These themes emerged from interview narratives, field observations, and document reviews. Overall, the data show that small-scale food industries already conduct several food safety practices, such as checking raw materials, cleaning equipment, controlling storage temperature, and separating production areas. However, these practices are often not supported by consistent documentation and structured verification. This situation creates a gap between actual food safety practices and formal HACCP requirements.

The first theme concerns the informal nature of HACCP implementation. Most participants understood the importance of maintaining cleanliness and preventing product contamination. However, their understanding of HACCP remained practical rather than systematic. Several business owners explained that they controlled food safety based on experience, habits, and visual inspection. One participant stated, "We usually know if the product is still good from its smell, texture, and color. We do not always write it down because we check it directly." This statement shows that sensory judgment remains central in small-scale production. Although such experience is useful, it may not be sufficient to meet HACCP principles, which require hazard identification, critical control point monitoring, corrective action, verification, and documentation.

Observation data confirmed this pattern. In several production units, workers checked raw materials before processing, but the inspection results were not recorded in a standard form. Some workers rejected damaged ingredients, but they did not document the reason, supplier name, batch number, or follow-up action. In the storage area, temperature control was performed using a thermometer, but the readings were not always recorded at fixed intervals. These findings suggest that small-scale industries tend to practice food safety as a routine activity rather than as a documented management system. This condition is consistent with Lee et al. (2023), who found that small and medium food enterprises often face difficulties in implementing food safety management systems because of limited resources, weak documentation, and insufficient technical knowledge.

The second theme relates to documentation constraints. Participants repeatedly mentioned that manual HACCP documentation was time-consuming, repetitive, and difficult to maintain during busy production hours. Workers often prioritized production targets over record completion. One production supervisor stated, “When orders are high, workers focus on finishing the product first. The form is sometimes filled in later.” This practice creates a risk because delayed documentation may reduce data accuracy. In several cases, records were completed based on memory rather than real-time observation. This finding indicates that documentation is not merely an administrative issue. It directly affects the reliability of HACCP monitoring.

Document review also showed that several forms were incomplete, inconsistent, or stored separately. Some businesses had sanitation checklists, temperature logs, and supplier records, but these documents were not connected to one another. As a result, it was difficult to trace whether a product problem was linked to raw material quality, processing temperature, worker hygiene, or storage conditions. This fragmented documentation limits the ability of businesses to conduct root cause analysis. In HACCP systems, documentation functions as evidence of control. Without accurate documentation, corrective actions become reactive and difficult to evaluate. Radu et al. (2023) emphasized that HACCP requires systematic monitoring and verification to ensure that food safety hazards remain under control.

The third theme shows that digital technology is perceived as useful, but only when it is simple and relevant to daily work. Participants generally welcomed the idea of digital HACCP because it could reduce paper use, simplify record storage, and make data easier to find. However, they did not expect highly complex systems at the early stage. Most participants preferred basic digital tools, such as mobile-based checklists, spreadsheet templates, WhatsApp reporting, QR code labels, digital thermometers, and simple cloud storage. One quality control officer explained, “For us, the most important thing is that the tool is easy to use. If the system is too complicated, workers will not use it during production.” This statement reflects the importance of usability in technology adoption.

Field observation supports this finding. Workers were more willing to use digital tools when the process only required a short input, such as selecting a checklist option, entering temperature values, or uploading a photo. In contrast, they were less comfortable with systems that required multiple login steps, long menus, or technical terms. This finding suggests that digital HACCP for small-scale industries should prioritize simple interfaces and short reporting procedures. Sartoni et al. (2025) argued that the digitalization of food safety management systems requires consideration of operational constraints, user competence, and organizational readiness. The present study confirms this point by showing that technology must fit the rhythm of production work.

The fourth theme concerns limited digital readiness. Although participants recognized the potential benefits of digital technology, several barriers affected their willingness and ability to adopt it. These barriers included limited budget, unstable internet connection, lack of digital skills, worker age differences, and uncertainty about data management. Some business owners worried that digital systems would require additional costs for devices, subscriptions, maintenance, or training. One owner stated, “We are interested, but we need to calculate the cost first. Small businesses cannot buy expensive systems immediately.” This statement shows that financial capacity strongly influences digital adoption in small-scale industries.

Digital literacy also emerged as a key issue. Younger workers were generally more comfortable with mobile forms and digital records, while older workers preferred paper forms because they were familiar with them. This difference created a potential gap in work practices. If digital systems are introduced without training, some workers may depend on others to complete records. This situation can reduce accountability and create uneven implementation. Therefore, digital HACCP should include training, mentoring, and gradual adaptation. The findings support Pai et al. (2024), who stated that food safety culture is influenced by employee engagement, communication, and leadership commitment. Digital readiness is not only about access to devices, but also about confidence, habit formation, and shared responsibility.

The fifth theme highlights the role of leadership and food safety culture. In businesses where owners and supervisors actively monitored production records, workers were more disciplined in completing HACCP documentation. Conversely, in businesses where documentation was treated as a formality, workers often filled out forms only before inspections or audits. One worker stated, "If the owner checks the record every day, we fill it in regularly. If not, sometimes we forget." This finding shows that leadership behavior shapes documentation discipline. Food safety culture becomes stronger when owners demonstrate consistent attention to hygiene, monitoring, and corrective action.

The data also show that workers follow routines established by supervisors. When supervisors provide clear instructions, use simple language, and give feedback, workers are more likely to understand why HACCP records matter. However, when HACCP is explained only as an audit requirement, workers tend to see it as extra paperwork. This finding indicates that the meaning of HACCP must be communicated as part of product safety and consumer protection, not merely as regulatory compliance. De Andrade et al. (2020) found that food safety culture varies according to organizational risk and management commitment. The present study supports this view and adds that digital tools can strengthen food safety culture only when leaders use the data for daily decision-making.

The sixth theme concerns the need for a gradual digital integration model. Based on interviews, observations, and document analysis, this study identifies five stages for integrating digital technology into HACCP systems in small-scale food industries. The first stage is mapping the production process and identifying critical control points. At this stage, businesses need to determine which processes carry the highest food safety risks, such as raw material acceptance, cooking temperature, cooling, storage, packaging, and distribution. The second stage is selecting simple digital tools that match the identified risks. For example, temperature control can begin with digital thermometers and electronic temperature logs, while traceability can begin with QR codes and batch numbering.

The third stage is worker training and role allocation. Each worker must understand what data should be recorded, when it should be recorded, and why the data matter. The fourth stage is routine implementation and digital monitoring. At this stage, data should be collected during production, not after production ends. The fifth stage is evaluation and corrective action. Business owners and supervisors should review digital records to identify repeated problems, such as temperature deviations, sanitation delays, raw material rejection, or packaging defects. This staged model allows small-scale industries to adopt digital HACCP without disrupting daily operations. It also reduces the risk of technology rejection because the system develops from existing routines.

The discussion of these findings suggests that digital HACCP should be understood as a socio-technical system. Technology provides tools for monitoring, documentation, and traceability, but the success of implementation depends on people, routines, leadership, and organizational learning. This finding strengthens the argument of Sartoni et al. (2025), who emphasized that the digitalization of food safety management systems requires technical and organizational enablers. In the context of small-scale industries, the main challenge is not only selecting digital tools, but also ensuring that workers can use them consistently during production. Therefore, the proposed model places human readiness and organizational habits at the center of digital HACCP integration.

The findings are also consistent with Patel et al. (2023), who argued that blockchain can improve transparency and traceability in food supply chains. However, this study shows that blockchain may not be the first priority for many small-scale food industries. Before adopting blockchain, businesses need basic data discipline, batch coding, supplier records, and digital documentation habits. Without these foundations, advanced traceability systems may not function effectively. This study therefore offers a more contextual perspective by suggesting that digital transformation in HACCP should begin from simple and affordable tools before moving toward complex technologies.

Similarly, the findings complement Revelou et al. (2025), who highlighted the potential of machine learning in food safety monitoring. Machine learning can support hazard prediction, risk classification, and early warning systems, but such applications require reliable and continuous data. In the small-scale industries examined in this study, the main limitation was not the absence of advanced analytics, but the weakness of basic data collection. Many records were incomplete, delayed, or scattered across different formats. Therefore, the first step toward intelligent HACCP systems is strengthening routine digital documentation. Once data quality improves, small enterprises may gradually adopt more advanced analytical tools.

From a theoretical perspective, this study contributes to food safety management literature by positioning digital HACCP as a process of organizational adaptation. The findings show that HACCP digitalization is shaped by the interaction between technology, work practices, leadership, and food safety culture. This perspective extends previous studies that focus mainly on technological capacity. It also supports the socio-technical view that technology adoption in organizations depends on the alignment between technical systems and social systems. In small-scale food industries, this alignment becomes especially important because organizational structures are simple, resources are limited, and decision-making is often centralized around the owner.

From a practical perspective, the findings suggest that small-scale food industries should not be encouraged to adopt expensive digital systems without first strengthening basic HACCP practices. The most realistic strategy is to introduce low-cost digital tools gradually. For example, businesses can begin with electronic checklists, digital temperature logs, cloud-based document storage, photo-based sanitation verification, and QR code batch labels. These tools can improve documentation and monitoring without requiring large investment. Government agencies, universities, and food safety consultants can support this process through training, mentoring, and simple digital templates tailored to small enterprises.

The findings also have policy implications. Food safety assistance programs for small-scale industries should not only focus on certification requirements or inspection results. They should also help businesses build digital capacity. Training programs should include practical modules on identifying critical control points, using mobile forms, managing digital records, analyzing deviations, and planning corrective actions. Local governments can develop standard digital templates that small businesses can use freely. This approach may reduce the administrative burden of HACCP implementation and improve compliance among small-scale food producers.

Despite its contributions, this study has limitations. The findings are based on qualitative data from selected small-scale food industries, so they cannot be generalized to all food sectors. Different types of products may have different critical control points, technological needs, and regulatory requirements. In addition, participant responses may be influenced by their desire to present their business positively. To reduce this limitation, the study used observation and document analysis to verify interview findings. However, further research is still needed to test the proposed model in broader industrial settings.

Future research should examine the implementation of the proposed digital HACCP model across different food product categories, such as dairy products, frozen foods, bakery products, meat products, and ready-to-eat meals. Comparative studies can also explore differences between urban and rural small-scale industries, especially in terms of internet access, digital literacy, and institutional support. Quantitative studies may measure the impact of digital HACCP on documentation accuracy, corrective action speed, audit compliance, product rejection rates, and consumer complaints. Mixed-method research can also provide a stronger understanding of how digital tools affect both food safety performance and worker behavior.

Overall, the results show that the integration of digital technology into HACCP systems can improve food safety in small-scale industries when it is designed according to the capacity, culture, and operational realities of the business. Digital tools can strengthen monitoring, traceability, documentation, and corrective action. However, successful implementation requires leadership commitment, worker participation, training, and gradual system development. Therefore, the proposed model emphasizes simple technology, staged implementation, and continuous evaluation as the foundation for sustainable digital HACCP adoption in small-scale food industries.

4. Conclusions

This study concludes that the integration of digital technology into HACCP systems can strengthen food safety management in small-scale food industries when it is designed according to operational capacity, worker readiness, and existing production routines. The main findings show that small-scale food businesses already conduct basic food safety practices, but these practices often remain informal, poorly documented, and dependent on individual experience. Digital tools can address these weaknesses by improving monitoring, documentation, traceability, and corrective action. However, the success of digital HACCP does not depend only on technology. It also requires leadership commitment, food safety culture, worker participation, and gradual system adaptation.

The study contributes theoretically by positioning digital HACCP as a socio-technical process that connects technology, organizational behavior, and food safety management. Practically, the proposed model offers a simple and staged approach for small-scale industries, beginning with digital checklists, temperature logs, batch coding, and electronic records before moving toward more advanced systems. From a policy perspective, the findings suggest that government agencies and food safety institutions should provide accessible training, mentoring, and low-cost digital templates for small food enterprises. Future studies should test this model across different food sectors and measure its impact on audit compliance, documentation accuracy, corrective action speed, and food safety performance.

References

Allam, M., et al. (2023). Assistance needed for increasing knowledge of HACCP food safety principles for organic sector in selected EU countries. *Sustainability, 15*(8), 6605. https://doi.org/10.3390/su15086605

Balamurugan, S., Ayyasamy, A., & Joseph, K. S. (2022). IoT-blockchain driven traceability techniques for improved safety measures in food supply chain. *International Journal of Information Technology, 14*, 1087–1098. https://doi.org/10.1007/s41870-020-00581-y

Braun, V., & Clarke, V. (2021). To saturate or not to saturate? *Qualitative Research in Sport, Exercise and Health, 13*(2), 201–216. https://doi.org/10.1080/2159676X.2019.1704846

Byrne, D. (2022). A worked example of Braun and Clarke's approach to reflexive thematic analysis. *Quality & Quantity, 56*, 1391–1412. https://doi.org/10.1007/s11135-021-01182-y

Campbell, S., et al. (2020). Purposive sampling: Complex or simple? *Journal of Research in Nursing, 25*(8), 652–661. https://doi.org/10.1177/1744987120927206

Cao, S., et al. (2023). Blockchain traceability for sustainability communication in food supply chains. *Sustainability, 15*(18), 13486. https://doi.org/10.3390/su151813486

Dasaklis, T. K., et al. (2022). Blockchain-enabled supply chain traceability implementations. *Sustainability, 14*(4), 2439. https://doi.org/10.3390/su14042439

de Andrade, M. L., et al. (2020). Food safety culture in food services. *Food Control, 112*, 107152. https://doi.org/10.1016/j.foodcont.2020.107152

Hassoun, A., et al. (2024). The fourth industrial revolution in the food industry. *Critical Reviews in Food Science and Nutrition, 64*(2), 407–437. https://doi.org/10.1080/10408398.2022.2106472

Hennink, M., & Kaiser, B. N. (2022). Sample sizes for saturation in qualitative research. *Social Science & Medicine, 292*, 114523. https://doi.org/10.1016/j.socscimed.2021.114523

Iftekhar, A., & Cui, X. (2021). Blockchain-based traceability system. *Foods, 10*(6), 1289. https://doi.org/10.3390/foods10061289

Johnson, J. L., Adkins, D., & Chauvin, S. (2020). Quality indicators of rigor in qualitative research. *American Journal of Pharmaceutical Education, 84*(1), 7120. https://doi.org/10.5688/ajpe7120

Lee, J. C., Neonaki, M., Alexopoulos, A., & Varzakas, T. (2023). Food safety management systems in SMEs. *Foods, 12*(17), 3218. https://doi.org/10.3390/foods12173218

Lobe, B., Morgan, D., & Hoffman, K. A. (2020). Qualitative data collection in an era of social distancing. *International Journal of Qualitative Methods, 19*, 1–8. https://doi.org/10.1177/1609406920937875

Lu, Y., Li, P., & Xu, H. (2022). Blockchain and IoT food traceability system. *Procedia Computer Science, 199*, 629–636. https://doi.org/10.1016/j.procs.2022.01.077

Nair, S. S., et al. (2023). Assessing food safety compliance in a small-scale food company. *Applied Sciences, 13*(22), 12190. https://doi.org/10.3390/app132212190

Pai, A. S., Jaiswal, S., & Jaiswal, A. K. (2024). Food safety culture in the food industry. *Foods, 13*(24), 4078. https://doi.org/10.3390/foods13244078

Patel, A. S., et al. (2023). Blockchain technology in food safety and traceability. *Heliyon, 9*(6), e16526. https://doi.org/10.1016/j.heliyon.2023.e16526

Radu, E., et al. (2023). Global trends and research hotspots on HACCP. *Heliyon, 9*(7), e18232. https://doi.org/10.1016/j.heliyon.2023.e18232

Revelou, P. K., Giaouris, E., & Skandamis, P. N. (2025). Machine learning applications in food safety. *Foods, 14*(6), 922. https://doi.org/10.3390/foods14060922

Sartoni, M., Semercioz Oduncuoglu, A. S., Guidi, A., Annosi, M. C., & Luning, P. A. (2025). Towards digitalisation of food safety management systems. *Food Control, 168*, 110952. https://doi.org/10.1016/j.foodcont.2024.110952

Singh, A., Gutub, A., Nayyar, A., & Khan, M. K. (2023). Redefining food safety traceability through blockchain. *Multimedia Tools and Applications, 82*, 21243–21277. https://doi.org/10.1007/s11042-022-14006-4

Zarid, M. (2025). The green HACCP approach: Advancing food safety and sustainability. *Sustainability, 17*(17), 7834. https://doi.org/10.3390/su17177834