

Towards Industry 4.0: A Guide to Digital Transformation for Food Sector SMEs in Brazil

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Abstract

Industry 4.0 emphasizes connectivity and digitalization, transforming business operations worldwide. In Brazil, however, the adoption of these technologies remains relatively limited, with only a small proportion of small and medium-sized enterprises (SMEs) fully engaging in digital transformation initiatives. Such engagement is critical to the national economy, yet SMEs face substantial barriers, including high implementation costs and limited technical expertise. This study focuses on SMEs in the food sector in São Paulo, aiming to provide strategic guidance for adopting Industry 4.0 practices and Information and Communication Technologies (ICTs) to support their technological transformation and improve digital maturity and competitiveness. To establish the theoretical foundation, a comprehensive literature review was conducted. This was followed by interviews with 10 food sector SMEs, using an online questionnaire of 21 questions organized into five categories: Technological Infrastructure, Automation, Management, Strategy, and Market. The results revealed that, while SMEs are interested in technologies such as QR codes, pagers, and social media, they face obstacles related to training, knowledge, and implementation costs. Nonetheless, they acknowledge the importance of digital transformation in their operations. Based on the data collected, a set of tailored recommendations was developed to support SMEs in planning and implementing effective digital transformation strategies.

Keywords: Industry 4.0, Small and Medium-sized Enterprises, Digital Transformation, Food Sector, Technological Adoption.

1 Introduction

Technological advances and the digitalization of products and services are reshaping business models and transforming the way consumers interact with products. Digital transformation is not solely a technological phenomenon; it is also organizational, leading to changes in corporate culture and management practices [1]. Moreover, it introduces new approaches and techniques for value creation, business remodeling, and the strengthening of customer relationships [2]. This transformation in production methods, known as the Fourth Industrial Revolution or Industry 4.0, is defined as an ecosystem built upon a diverse array of technological systems and interconnected multidisciplinary innovations, capable of rapidly transmitting and receiving information, thereby facilitating the automation of decision-making processes [3].

Brazilian Industry 4.0 is still in a developmental phase and "remains behind compared to other countries" [4]. In the Brazilian business context, it is estimated that at least 69% of companies employ some form of digital technology. However, despite this significant percentage, most adopt only a limited number of such technologies, indicating that they remain in the early stages of digitalization [5]. Supporting this statistic, a survey conducted with SMEs in the food sector in the city of São Paulo found that 82% of establishments had implemented some type of automated sales system or software application; nevertheless, only 64% believed that the use of an automated system would be beneficial for their business [6].

According to the National Confederation of Industry (CNI) in 2022 [5], in the food sector, the main internal barriers to the adoption of digital technologies include organizational structure and culture, as well as the high cost of implementation. Among the external barriers, the most prominent are the lack of market preparedness (customers and suppliers), the difficulty in identifying suitable technologies and partners, and the shortage of qualified workers. Among companies that have already incorporated some type of technology into their production processes, the most frequently cited benefits are the reduction of operational costs, improvement in the quality of products or services, and increased productivity.

Promoting the digital transformation of Brazilian small and medium-sized enterprises (SMEs) in the food sector is a critical step toward advancing the implementation of Industry 4.0, thereby strengthening their relevance and competitiveness in the national market. In this context, the present study identifies and systematizes a guide of recommendations for the adoption, resource management, and implementation of specific Information and Communication Technology (ICT) solutions capable of fostering the technological transformation of small and medium-sized enterprises (SMEs) in the food sector, specifically those operating in food court sales. This guide was developed based on a comprehensive literature review and interviews with SMEs active in the food sector in the city of São Paulo.

This article is an extended version of the paper published in the Proceedings of the Ibero-American Conference on Human-Computer Interaction 2025, held in Mexico. It is structured as follows: Section 2 presents the theoretical concepts underpinning this research and related work. Section 3 describes the methodology employed. Section 4 discusses the data collected from interviews conducted with companies. Section 5 presents the recommendation guide for the digital transformation of SMEs in the food sector. Finally, Section 6 provides the concluding remarks and outlines directions for future research.

2 Theoretical Framework

This section presents the concept of Industry 4.0 and reviews related studies on the adoption of Industry 4.0 and digital transformation in small and medium-sized enterprises (SMEs) in Brazil. In addition to this section, reference [7] presents a literature mapping carried out during this research, showing the results on the adoption of Industry 4.0 practices by small and medium-sized companies.

2.1 Industry 4.0

Industry 4.0 refers to a transformation in the production sector through the automation of processes and the integration of digital technologies such as the Internet of Things (IoT), Big Data, Artificial Intelligence (AI), Cloud Computing, and Cybersecurity, among others [8] [9]. The combination of these technologies leads to paradigm shifts in organizational structure, management, culture, strategy, production, and consumption, based on interoperability and the optimized use of technologies aligned with business demands [8] [10]. Industry 4.0 is not limited to the production stage but extends across the entire value chain, integrating manufacturing and distribution processes with post-sales services, including customer satisfaction, maintenance, and product or service loyalty [4].

Digital transformation requires rethinking traditional business models and involves a fundamental reconfiguration of how companies operate, compete, and create value [10]. It demands that organizations reconsider their organizational structure, decision-making processes, and customer engagement strategies through the implementation of technological tools. It entails the creation of new ways of delivering value to

customers, redesigning supply chains, and restructuring internal operations for greater agility. To achieve this, it is essential to establish a technology adoption strategy aligned with business objectives, fostering a sustainable competitive advantage [10].

2.2 Related Work

The contribution by Eliseo et al. [7] presents a literature review on guidelines and procedures for the adoption of Industry 4.0 within small and medium-sized enterprises (SMEs) in Brazil. The authors report that the development of Industry 4.0 in Brazil remains in its early stages and is still largely confined to the context of large corporations. They emphasize that overcoming the barriers faced by SMEs in adopting Industry 4.0, such as the high costs of technologies and the lack of awareness regarding their benefits, requires the establishment of joint initiatives between public and private organizations, as well as targeted guidance to support these companies in their digital transformation.

Chandratreya [10] presents a literature review that explores the strategy and management of digital transformation, emphasizing the critical role of strategic alignment and leadership in the success of transformation initiatives. The author highlights the need for a strategy that integrates technology investments with organizational objectives to achieve competitive advantage. The study reveals that digital transformation goes beyond mere technological adoption, requiring fundamental changes in organizational culture, structure, and strategy. The success of digital transformation depends on visionary leadership and effective change management, fostering a culture of agility, innovation, and continuous learning. However, the studies also identified barriers to transformation, such as resistance to change, legacy systems, and strategic misalignments. The author concludes that a well-defined, agile, and continuously evaluated digital strategy is essential for organizational resilience and long-term success in the digital economy.

Fassini [11] analyzes the impact of adopting Industry 4.0 technologies on the innovation of SME business models. The research includes multiple case studies, featuring interviews with experts and SME representatives. The results reveal several factors influencing SME adoption of Industry 4.0 technologies and their impact on business innovation. The study underscores the role of technological understanding in SME business model innovation and competitiveness. The findings provide valuable insights for managers, stressing the importance of technology for competitiveness and suggesting policies for technology adoption to foster SME development and market positioning.

Vrontis, Chaudhuri, and Chatterjee [12] investigated how the adoption of various digital technologies by SMEs can influence both economic and social value creation, and how this value creation affects SME performance. The main findings of the study demonstrated that the adoption of digital technologies such as social media applications, AI-enabled tools, big data analytics, and Internet of Things (IoT) applications has a positive impact on the creation of economic and social value for SMEs. The study confirmed that both economic and social value creation positively influence SME performance. Finally, the research revealed that the implementation of digital transformation must emphasize how to integrate emerging digital technologies within the context of business needs, focusing on hybrid approaches, recombination, integration, and convergence.

This study distinguishes itself from related work by proposing a structured set of recommendations for the digital transformation for adopting Industry 4.0 practices, specifically tailored to the operational realities of SMEs in food sector. Its primary objective is to assess the digital maturity of these businesses and provide strategic guidance for the adoption of technologies that enhance their growth potential and competitive positioning.

3 Methodology

This study employs a mixed-methods approach, combining qualitative and quantitative methodologies. The qualitative aspect is reflected in the adoption of a systematic literature mapping procedure to gather the theoretical foundation necessary to support the development of the recommendation guide. The systematic mapping enabled the identification and analysis of 19 relevant articles, from which insights and trends related to technology adoption by SMEs in Brazil were extracted. This systematic mapping is not presented herein, as its results have been published in a separate article [7]. The quantitative aspect is emphasized through the collection and analysis of data obtained from interviews, conducted via an online questionnaire, with SMEs. For these interviews, a questionnaire comprising 21 questions filtered from two repositories, Brasil [13] and ABDI [14], was administered to 10 companies in the food sector located in São Paulo. The results of these interviews were used to examine the relationship between SMEs and the technologies and practices of Industry 4.0. This research also takes on an exploratory dimension, seeking to examine the relationship of SMEs with technology adoption, assess their specific needs, and derive targeted recommendations to

facilitate the integration of Industry 4.0 within the food sector, thereby providing the basis for the proposed guidelines.

The systematic literature mapping sought to identify the existence of guidelines, recommendations, or frameworks that assist SMEs in adopting technologies to transition toward Industry 4.0, guided by the following research question: What are the guidelines or procedures for small and medium-sized enterprises to transform into Industry 4.0? Based on this research question, a search string was formulated. The search was conducted across databases without distinguishing between grey and white literature, including Google Scholar, Google, DuckDuckGo, and Periódicos CAPES (a Brazilian database). Following the search, less relevant findings were excluded, including those that did not address the digital transformation of SMEs to foster Industry 4.0 implementation, articles that did not present a primary study, and duplicate records. After applying the exclusion criteria, 19 articles were selected and analyzed [7].

To complement the findings of systematic literature mapping, an online questionnaire was designed to investigate the use of technology and Industry 4.0 processes by SMEs in their daily operations, capturing their experiences, challenges and practices. These insights were then aligned with the recommendations identified through the systematic mapping.

The questionnaire was developed based on studies by Brasil [13] and the Brazilian Agency for Industrial Development (ABDI) [14], both of which provide guides containing question repositories intended to support SMEs in adopting Industry 4.0 practices. The questions are broad in scope and applicable to companies of varying sizes and levels of maturity, encouraging entrepreneurs to reflect on their business operations. The Brasil [13] study categorizes its questions into five groups: vision and direction, culture and engagement, structure and processes, resources, and infrastructure. In turn, the ABDI [14] study organizes its questions into categories defined by the research team to facilitate understanding: data-driven organization, customer value and connection, competitive foundations, and enabling technologies. Together, these studies contributed to a consolidated repository of 115 questions.

The selected categories and questions were filtered with consideration of the SME context, particularly their resource constraints. Each question was evaluated for its relevance to SMEs, taking into account their industry, size, and available time. Ultimately, 21 questions were selected and organized into five new categories, defined by the research team to encompass the key areas emphasized in the reference studies:

- **Technological Infrastructure, Tools, and Applications:** Comprising four questions, this category aims to understand the current relationship of SMEs with essential Industry 4.0 technologies;
- **Automation and Integration:** Containing two questions, this category seeks to determine the level of data integration within business processes, evaluating automation and system integration capabilities;
- **Management and Organizational Culture:** With four questions, this set aims to assess whether company management adopts Industry 4.0 practices and whether there is a way to measure the application of these technologies;
- **Strategy and Innovation:** Including three questions, this section explores whether companies actively seek innovation, how they intend to leverage it, and how they promote their services;
- **Market and Customers:** The largest category, with eight questions, focuses on understanding the company market presence, customer interactions, awareness of competitors, and use of technological tools to stay competitive.

These questions aim to deepen and complement the findings of the systematic literature mapping, providing a more specific overview of digital transformation for the implementation of Industry 4.0 in SMEs within the food sector. The responses from the interviewed companies were analyzed to offer support for the development of the recommendation guide, ensuring it better addresses the needs of the companies.

3.1 Research Participants

For the interviews, specific selection criteria were established for participating companies, such as having between 10 and 99 employees, in accordance with the classification established by Sebrae [15]. Companies were required to operate in the food sector, which is the focus of this study, and be located in the central region of São Paulo city, constituting a convenience sampling approach to facilitate company contact. It is noteworthy that São Paulo concentrates a large number of companies, including those in the food sector, particularly in its central area.

Although several companies were contacted, only ten agreed to participate in the study. The research team primarily conducted interviews with business owners or alternatively, with the employee responsible for managing the operations of the establishment. It was clarified that all information collected would remain confidential, and participants were free to accept or decline participation in the interview.

3.2 Research limitations

Although many food sector companies located within the research area were invited to participate, few responded positively. Additionally, among those that agreed to participate, not all answered every question in the questionnaire, limiting the information collected and potentially not representing the complexity and diversity in the adoption of digital transformation. The companies that did not answer all the questions were not discarded, as the sample size was small, and even though some questions were ignored, the responses obtained were important for data analysis. Furthermore, the participating companies are located in the central region of São Paulo, and therefore may not represent the reality of Brazil, which is a highly diverse country. The research is also limited to a specific sector, the food industry. Moreover, the recommendations indicated were not validated. Furthermore, the responses may be subject to biases, as companies might have answered in a way they perceived as more favorable or may have underestimated or overestimated their practices and perceptions.

4 Interview Findings

The objective of this research conducted with companies was to collect data, along with the results of the systematic literature review [7], to support the development of a guide that helps SMEs in the food sector, especially those selling food in food courts, improve their processes within the context of Industry 4.0. The questionnaire, consisting of 21 questions and divided into five categories. Below are the 21 questions divided into their categories.

Technological Infrastructure, Tools, and Applications

- Does your company use automated service tools? Which tools are used?
- Does your company sell products or services using digital platforms? Which digital platforms do you use?
- Do you feel the need to implement technologies to improve your business? If yes, what type of technology? If not, why do you not use technology?
- Does your company use any software for storing and sharing data on purchases, products, trends, and other relevant information? For which purposes does your company use these data?

Automation and Integration

- Does the company have any automated processes? Which processes are digitized?
- Are the information and activities of the company digitally integrated? What types of activities are integrated?

Management and Organizational Culture

- Does your company have a management system that unifies the databases of all areas? Which management systems are used?
- Does your company use digital means to share information and communicate with employees? List the tool you use most frequently.
- Do you have any way to evaluate the results of using technology in your business? How satisfied are you with the results of using technology in your business?
- Does the company use IT professionals or consulting services? What types of services are used?

Strategy and Innovation

- Do you want to include innovations in any area of your business? In what ways do you intend to include innovations?
- Do you feel the need to implement new technologies to improve your business? Which technologies are you interested in implementing?
- Does the company use marketing actions to promote new products or services? What actions are used to promote new products or services?

Market and Customers

- Does your company monitor digital media to understand how customers interact with your product or service? How often do you monitor digital media?
- Does your company use digital means to share information and communicate with customers? Which application(s) do you use most frequently to communicate with customers?
- Does your company use customer information to offer promotions? What customer information is used?
- Does the company keep a record of customer purchases? How is customer purchase information recorded?
- Does the company strive to remain competitive in relation to its competitors? In what ways does the company strive to remain competitive?
- Does the company seek to analyze and meet new demands and preferences of current and potential customers? How does the company analyze new trends?
- Have you ever conducted or do you conduct market research to better understand your competition? How have you conducted or do you conduct market research?
- Does your company maintain contact with customers on digital media and follow their suggestions and trends? Which digital media do you use?

4.1 Technological Infrastructure, Tools, and Applications

To identify the use of digital infrastructure, tools, and applications, and to understand the relationship of companies with Industry 4.0 technologies, four questions were developed. For Question 1, *"Does your company use automated customer service tools?"*, only 20% of the companies responded "yes," as shown in Fig. 1. Among these, the most commonly used tools were QR codes (50%) and self-service kiosks (100%).

Does your company use automated service tools?

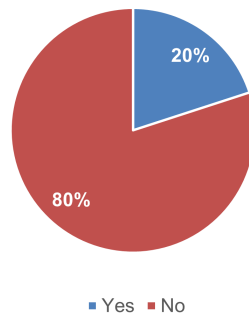


Figure 1: Use of automated service tools by companies

For the question "Does your company sell products or services using digital platforms?", 10% responded affirmatively (Fig. 2), indicating a low level of utilization of digital resources to support sales. This may be due to a lack of awareness regarding the potential of these technologies to assist in sales processes, as discussed in Chandratreya [10].

Does your company sell products or services using digital platforms?

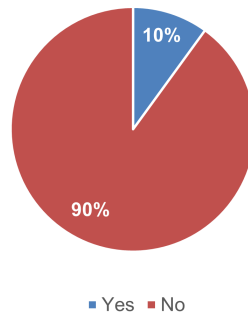


Figure 2: Use of digital platforms to support sales

However, 88.9% of the interviewed companies expressed the need to implement technologies to improve their business operations, as shown in Fig. 3. Fig. 4 illustrates both the intention to adopt technology in business and the interest in implementing new solutions. SMEs demonstrated particular interest in widely adopted tools such as QR codes and social media (66.7%), pagers, AI (Artificial Intelligence), and cloud computing (33.3%), automated communication systems (22.2%), as well as emerging technologies such as robotics (22.2%).

Do you feel the need to implement technologies to improve your business?

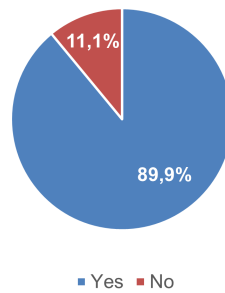


Figure 3: Perceived need to implement technologies for business improvement

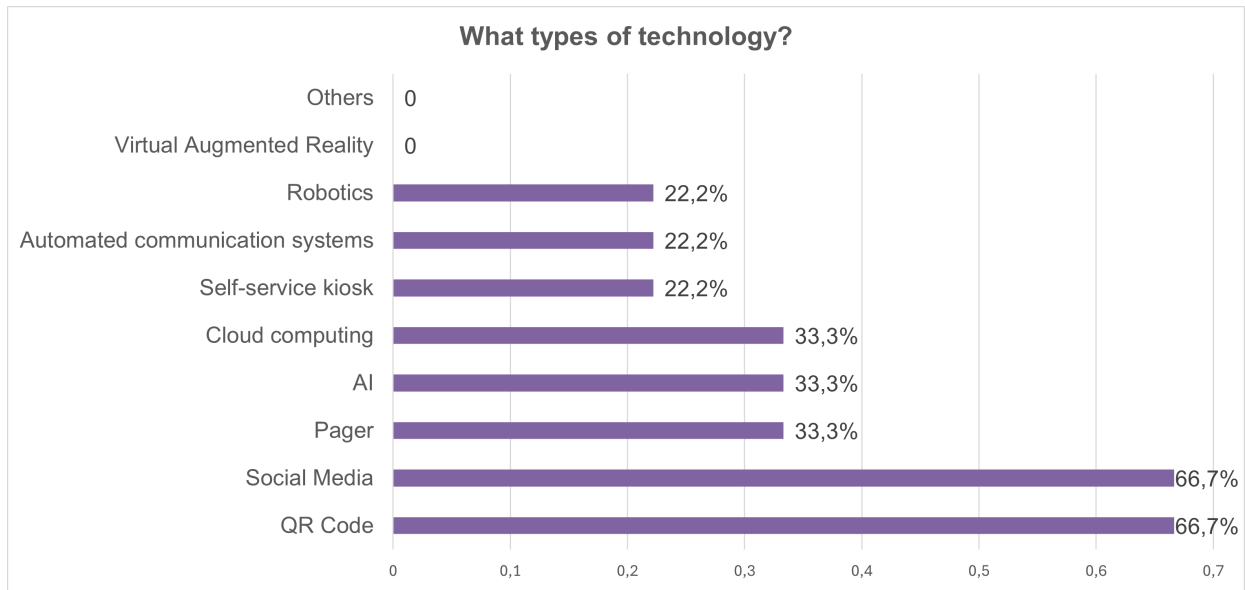


Figure 4: Types of technology companies intend to use

When asked why they do not use technology, 70% of the surveyed companies stated that acquiring technology is too expensive, 60% reported difficulties in using it, 30% do not believe technology will benefit their business, and 20% admitted being afraid and unwilling to take risks (Fig. 5). These findings highlight the need for simpler and more accessible solutions to reduce both financial and time-related costs. The main challenges include a lack of adequate training, unfamiliarity with new technologies, and the perception of high financial investment requirements, among others. Similar barriers are also reported by Chandratreya [10].

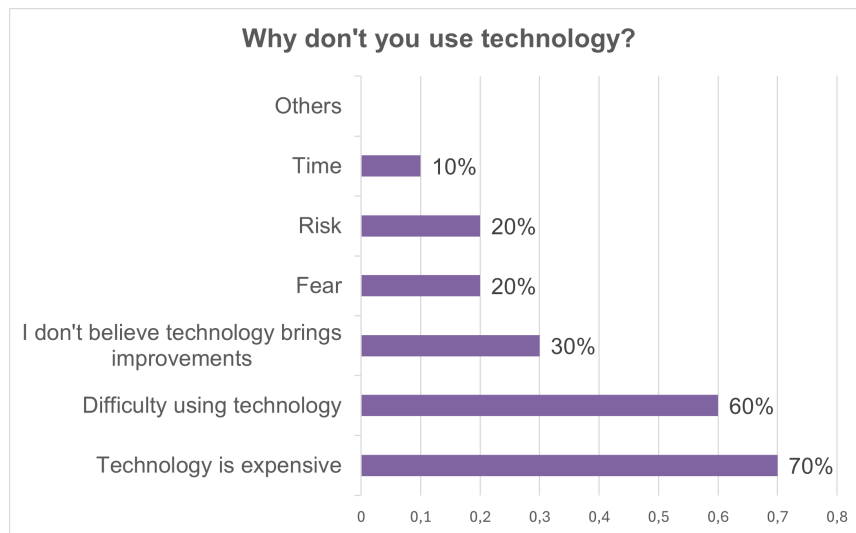


Figure 5: Reasons why SMEs do not implement new technologies

Thirty percent of the companies surveyed reported using software for the storage and sharing of data related to purchases, products, trends, and other business information, as shown in Fig. 6. Among the companies that use such software, 66.7% employ internal communication, inventory tracking, and customer contact tools, while 33.3% use software for market research (Fig. 7).

Does your company use any software for storing and sharing data on purchases, products, trends, and other relevant information?

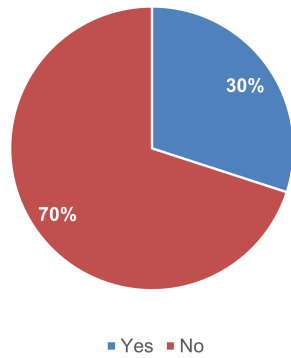


Figure 6: Use of software for storing and sharing data on purchases, products, and trend

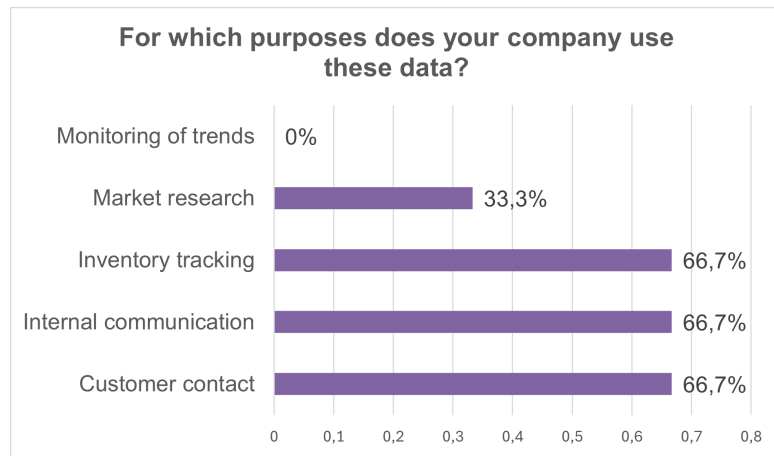


Figure 7: Purpose of data use

An analysis of the technological infrastructure and the use of tools and applications reveals that the surveyed SMEs in the food sector are still at an early stage of digital transformation. Although most of them use some form of technology, they do not fully leverage technological resources to optimize business processes, despite expressing interest in implementing them. However, fear of taking the risk of investing in technology, coupled with a lack of digital literacy and awareness of its potential, has led companies in the food sector to hold back from advancing their digital transformation, as evidenced by the findings of Passos [4], CNI [5], and Gunji et al. [6].

4.2 Automation and Integration

Regarding automation and integration, two questions were formulated. The first investigated whether the company had any automated processes. Fifty percent responded affirmatively. Among those, 80% reported automating product selection and purchasing; 60% automation in preparation; 40% in inventory management; and 20% in sanitation and cleaning, packaging, ordering, and customer service, as shown in Fig. 8.

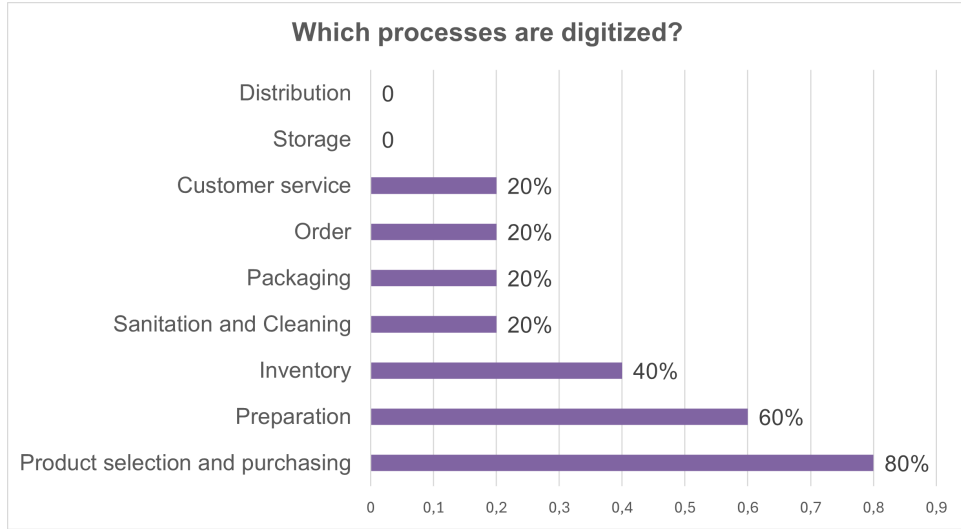


Figure 8: Digitized processes

The second question concerned the digital integration of information and activities, with 40% of the companies stating that they had some level of integration. Of these, 75% reported integration in product preparation; 50% in inventory, storage, and distribution; and 25% in product selection and purchasing (Fig. 9).

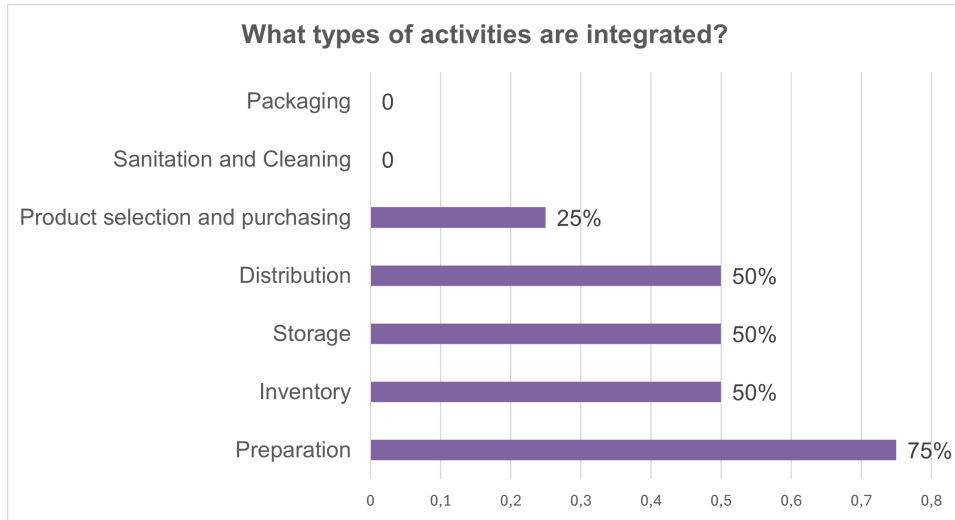


Figure 9: Integrated activities

Based on the responses, it can be inferred that the surveyed companies are still in an incipient stage of automation and integration. Their digital processes remain fragmented, which may lead to suboptimal results, corroborating the findings of Chandratreya [10].

4.3 Management and Organizational Culture

Management and Organizational Culture were analyzed based on four questions. When asked whether the company had a management system that unified the databases of all areas, 100% of the interviewed companies responded negatively. This indicates that SMEs in the food sector still adhere to traditional management models, meaning they have not yet broken through the barriers of digitalization in this regard. It should be noted that some of these companies have a family-based management structure, which tends to be even more resistant to innovation, as pointed out by Fassini [11] and Chandratreya [10].

When asked about the use of digital means to share information and communicate with their employees, 50% responded affirmatively, with WhatsApp, Telegram, and email being the most frequently used tools.

Regarding the assessment of the results of technology use in business, only 40% of the interviewed companies answered positively. Of these, 25% reported being very satisfied with the results, 50% satisfied,

and 25% neutral. Analyzing these results, it is evident that although there is general satisfaction, a portion of companies has not yet been able to perceive the benefits of technology adoption in their business operations.

Among the companies surveyed, only 10% make use of IT (Information Technology) professionals or consulting services, specifically for software development, IT planning, and infrastructure. None of the companies employ security consulting or recovery planning services, as shown in Fig. 10.

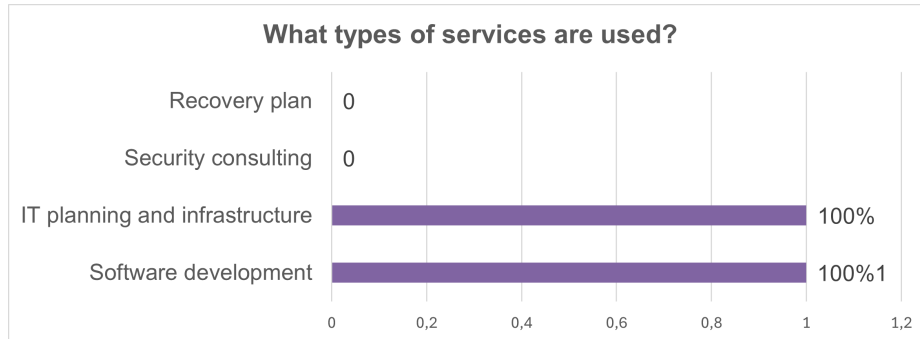


Figure 10: Services employed

From these findings, it can be inferred that companies still follow traditional business models and are resistant to change. SMEs do not foster a culture of innovation and collaboration, which hinders their ability to adapt to digital transformations [10]. This lack of flexibility, coupled with decision-making based on the personal market perceptions and beliefs of manager, reflects a limited awareness of the changes necessary for innovation [11]. Management must identify and properly assess the dynamic changes in both internal and external environments before investing in technological capabilities [12].

4.4 Strategy and Innovation

To analyze Strategy and Innovation, three questions were selected. When asked whether they intended to incorporate innovations in any area of their business, 90% responded affirmatively, indicating that a portion of respondents remains resistant to change. Among those who answered "yes" to this question, the most desired initiatives included the automation of food production (44.4%), order processing (33.3%), and inventory control (44.4%), as well as the inclusion of a digital menu (66.7%) and digital customer service (55.6%). Only 33.3% of the interviewed companies expressed interest in implementing an integrated management system. These responses indicate that the willingness to digitalize processes is still incipient and primarily oriented toward streamlining customer service demands, as discussed in Gunji et al. [6].

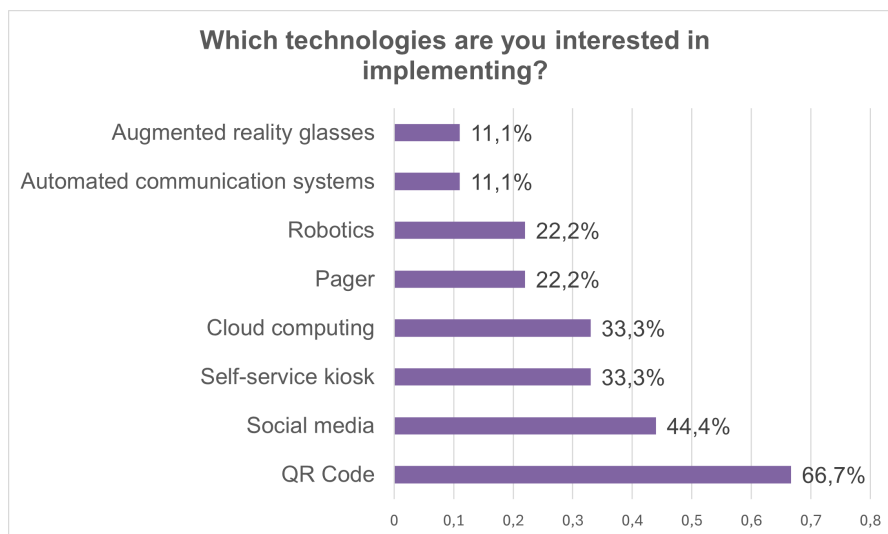


Figure 11: Technologies of interest for future implementation by the surveyed companies

Despite this resistance to change, when asked whether they felt the need to implement new technologies to improve their business, 90% once again responded affirmatively. Reported technological interests included

the use of QR codes (66.7%), social media (44.4%), service kiosks and cloud computing (33.3%), robotics (22.2%), automated communication systems, and augmented reality glasses (11.1%), as shown in Fig. 11.

The adoption of digital marketing strategies to promote new products or services remains limited, with only 20% of the interviewed companies engaging in such activities. Similarly, only 20% monitor social media to understand how their customers interact with their products or services. Among those who reported monitoring social media, half do so occasionally (50%), while the other half do so weekly (50%). These results reveal an underutilization of digital tools for business communication, as well as a lack of structured digital marketing and promotional practices. Digital marketing plays a key role in brand building and in enhancing the overall development of commercial activities [12].

4.5 Market and Customers

Regarding Market and Customers, eight questions are analysed. Only 20% of companies monitor social media on a monthly or occasional basis to understand their customers's interactions with their products or services. Of the companies interviewed, 30% use digital means to share information and communicate with their clients. Among those who responded affirmatively, communication channels include WhatsApp, Telegram, Facebook, and Instagram (33.3%), while 66.7% use a website, as shown in Fig. 12.

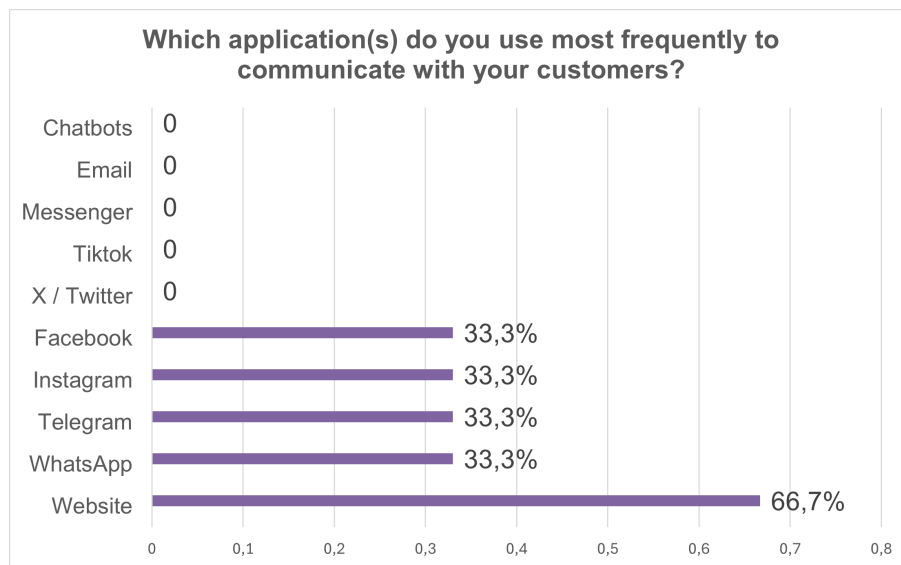


Figure 12: Most used applications to communicate with customers

Despite demonstrating limited engagement through digital channels, 70% of the surveyed companies utilize customer information to offer promotions. Of those who answered "yes" to this question, 100% recognize customer interests, 71.4% perceive current demand, and only 28.6% use purchase history data.

All interviewed companies (100%) reported maintaining records of customer purchases. These records are kept manually in notebooks (60%), automatically in databases (30%), and through stock purchases (10%).

When asked about competitiveness, 90% claimed to maintain a competitive position relative to their rivals. These companies attribute their competitiveness to launching new products (77.8%), conducting market research (55.6%), promoting marketing actions (33.3%), innovating processes, and organizing promotions and raffles (22.2%), as shown in Fig. 13.

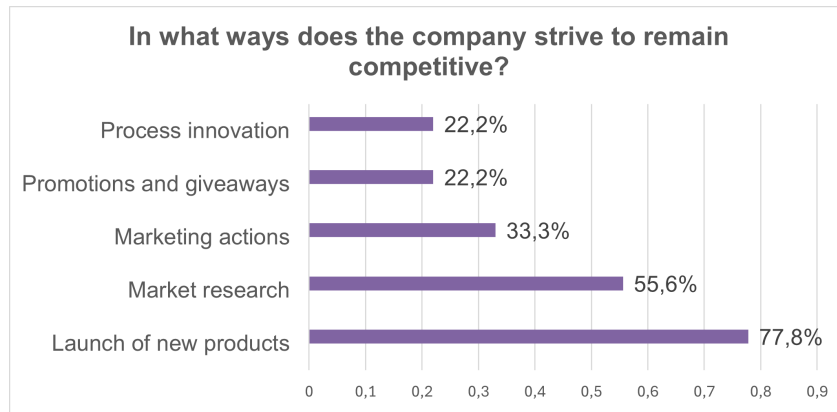


Figure 13: Ways in which the company strives to remain competitive

Ninety percent of the interviewed companies seek to analyze and meet the new demands and preferences of current and potential customers. To achieve this, they maintain constant customer contact (100%), conduct market research (44.4%), and monitor digital media (22.2%).

However, only 60% of the companies have conducted or are conducting market research to better understand their competition. None have hired external consulting services for this purpose, but 83.3% interview customers of competitors, 50% purchase products or services of competitors and rely on analyses from industry professionals, and 23% track trends through social media.

Regarding maintaining contact with customers through digital media to monitor suggestions and trends, only 20% perform this monitoring. Among these, all (100%) use the complaints and compliments section on the website of the company, and 50% use Instagram and Facebook.

It is evident that the interviewed SMEs consider themselves competitive relative to their competitors, yet they do not invest in market research, which may result in a distorted perception of their competition and business potential [11]. Nevertheless, an online presence through social media and digital marketing strategies could be a differentiating factor to boost their competitiveness [10].

Based on the collected data, this study sought to understand the relationship of the surveyed companies with digital transformation and the Industry 4.0 landscape. These results contributed to identifying the necessary recommendations for food sector SMEs to consciously and strategically adopt digital transformation strategies, aiming to become efficient and effective. It is expected that the guide will enable SMEs to develop a personalized action plan to improve their digital maturity, allowing them to compete efficiently and more sustainably in an increasingly automated and digitized environment.

5 Guidelines for Food Sector SMEs to Adopt Industry 4.0 Practices

Following the analysis of the 19 articles from the literature mapping, the findings revealed that digital maturity models play a key role in understanding how digital maturity influences SMEs. The studies also identified recurring challenges in the implementation of new technologies, including the lack of adequate infrastructure, resistance to change, insufficient digital literacy, high investment costs, and limited awareness of the actual added value of such technologies. Additionally, the adoption of ICTs and Industry 4.0 practices was associated with significant benefits, such as improved product quality, increased efficiency, enhanced customer engagement, and overall profit growth [7].

The recommendations were organized into the five categories analyzed in the interviews: Technological Infrastructure, Tools, and Applications; Automation and Integration; Management and Organizational Culture; Strategy and Innovation; and Market and Customers.

5.1 Technological Infrastructure, Tools, and Applications

This subsection lists technologies that offer rapid integration and are commonly used in the daily operations of SMEs in the food sector, facilitating data sharing, automating processes, and promoting business growth.

- **QR Code:**

What it is: A printed code that can be scanned with a mobile device equipped with a camera. This code stores information such as text, URLs, locations, emails, contacts, among others.

Purpose: Used to access a digital menu, place orders, make payments, and provide access to the website of company.

Benefits: Increases customer engagement with the business.

Implementation: QR Codes are created using online QR Code generators. The generated image can be printed and placed on the service table. The customer points the camera of their mobile device at the code to access the stored information. An internet connection is required to access the service.

Approximate cost in dollars: \$10 for implementation plus \$0.10 for printing each QR code.

Training and adaptation cost: quick and simple, as it only involves the creation and use of QR codes.

- **Pager:**

What it is: A wireless electronic device that receives messages in the form of audible alerts, visual signals, or vibrations.

Purpose: Used to manage the waiting queue upon arrival at the establishment or after placing an order. The device emits a sound, visual signal, or vibration to notify the customer that their place is available or their order is ready for pickup.

Benefits: Reduces queues and crowding, enhances customer comfort during waiting times, and optimizes service efficiency.

Implementation: The customer receives the pager upon arrival or order placement and can wait elsewhere until called. When the table is available or the order is ready, the attendant inputs the pager code into the transmitter, which transmits a signal to the customer pager. The pager alerts the customer, who then returns, returns the device, and receives service.

Approximate cost in dollars: between \$100 and \$400.

Training and adaptation cost: it may take a few weeks for employees to get used to it.

- **Self-Service Kiosk:**

What it is: An electronic self-service station that allows customers to place orders independently without interacting with staff.

Purpose: Enables customers to place orders and make payments via the kiosk.

Benefits: Speeds up service processes, allows employees to focus on order preparation, and reduces queues.

Implementation: Implementation requires contracting a service provider who assists in selecting the installation location, configuring and customizing the kiosk, and providing technical support. The establishment must have an internet connection to operate the service.

Approximate cost in dollars: between \$400 and \$1,600.

Training and adaptation cost: it may take up to one month for full integration into the workflow.

- **Digital Menu:**

What it is: A digital version of the physical menu.

Purpose: Allows customers to view offered products via their mobile devices, place orders, and even make payments. It can be integrated with QR Codes to facilitate customer access.

Benefits: Eliminates printing costs, enables real-time updates of prices, new items, and descriptions, and optimizes establishment management by generating reports on orders, inventory, and sales. It can also collect customer experience data during their visit.

Implementation: Can be implemented by contracting a technology company or using a digital platform to create the menu. Adoption involves staff training for proper use.

Approximate cost in dollars: free to \$100 for creation; between \$80 to \$400 per device.

Training and adaptation cost: it may take several weeks for full adaptation, depending on how familiar the company is with portable devices and applications.

- **Online Sales Platform:**

What it is: A digital system for managing online sales.

Purpose: Facilitates online sales transactions.

Benefits: Can increase customer reach through online sales and deliveries and optimize management via inventory control, financial management, and order data analysis.

Implementation: The establishment can register on an online sales platform and use its services.

Approximate cost: estimated at 10% to 30% of the product sold.

Training and adaptation cost: It may take up to one month for full adaptation into the workflow.

- **Social Media:**

What it is: Digital platforms that enable connection and interaction between people and businesses, allowing information sharing.

Purpose: Improves communication with customers by making it more direct and personalized. Businesses can showcase products, ambiance, news, promotions, and more.

Benefits: Increases visibility, attracts new customers, and strengthens relationships with existing customers.

Implementation: Create a business profile on a social media platform and interact with customers.

Approximate cost: there may be advertising costs (variable).

Training and adaptation cost: Quick adaptation at the beginning, but the level of difficulty tends to increase as new tools are discovered.

5.2 Automation and Integration

Process automation is one of the defining characteristics of Industry 4.0, highlighting the integration of technology and information in business operations. This section identifies processes that can benefit from automation, making daily operations more efficient:

- Inventory control systems (BLing, Tiny, IBM Cloud Pak)
- Order distribution (Self-service kiosks, queue management systems, order apps)
- Delivery services using apps (iFood, Rappi, etc.)
- Product storage solutions

5.3 Management and Organizational Culture

As important as knowing which technologies can drive digital transformation in a business is ensuring that they are effectively integrated into the routine of company. No transformation takes place without proper preparation for the innovation process. Therefore, it is crucial to ensure that the company has a culture that is receptive to adopting new practices and that employees are genuinely committed to learning new processes. In this regard, the following recommendations are highlighted:

- Use of messaging apps for communication between employees and sharing relevant information. Apps like WhatsApp and Telegram can be used for quick and informal communication, facilitating information exchange and task organization, while email can be used for sending important documents and recording official conversations. Messaging services like WhatsApp and Telegram can cost \$4.99 per month, and corporate email services can range from \$6 to \$27 per user.
- Implementation of a management system, preferably an ERP system, to control sales and business activities. This system integrates all company areas, enabling greater centralization of information (sales and inventory tracking, order management, and detailed reporting), improving decision-making. The cost of implementing these services can range from \$200 to \$100,000, plus a monthly plan that can vary from \$10 to \$3,500. These amounts depend on the scope of the contracted service, complexity, number of modules, and customizations.
- Hiring IT consultancy services to implement, maintain, and evaluate the use of technologies, especially management systems. IT consultants can provide continuous support to ensure technologies function efficiently, measure performance, and suggest improvements. The implementation of IT consultancy services for technology management systems involves significant cost variability. Hourly rates for IT consultants typically range from \$70 to \$160, with specialized expertise reaching up to \$200 per hour. Project-based engagements exhibit even broader variation: small-scale projects may cost between \$1,500 and \$5,000, while medium-complexity implementations range from \$8,000 to \$25,000. Large-scale enterprise resource planning (ERP) deployments, which often require extensive customization and integration, can exceed \$50,000 and reach over \$100,000. These figures underscore the influence of project scope, technological complexity, and customization requirements on overall expenditure.

5.4 Strategy and Innovation

This section discusses how businesses can use the information obtained through digitalization to analyze key areas and improve performance. It is recommended that, alongside digital transformation efforts, businesses start with low-cost technologies and practices such as social media apps, QR codes, delivery apps, and inventory systems. Additionally, companies should evaluate the impact of these changes by asking:

- How well have employees adapted to new technologies?
- Have there been gains or losses in information processing due to the introduction of new technology or practices?
- Has the new technology/practice provided new insights into customer behavior?
- Has the new technology or practice provided new insights into market trends?
- Based on the data collected, can process improvements be suggested? By addressing these questions and conducting a critical analysis of the transformation process, companies can develop strategies to maintain and improve their operations.

5.5 Market and Customers

To remain competitive, SMEs in the food industry must adopt a proactive digital approach. Digital platforms help businesses connect with customers, understand consumption trends, and expand their reach. Social media platforms like Instagram, TikTok, and Facebook allow businesses to engage with consumers, share relevant content, and creatively promote products. Maintaining a strong online presence not only attracts new customers but also strengthens loyalty among existing ones.

Some useful technologies and tools for SMEs include:

- Google Analytics (Free tool for analyzing website traffic)
- Google Alerts (Allows businesses to set up alerts to monitor online mentions of their brand, products, or competitors)
- Simple Data Analysis Tools (Spreadsheets like Microsoft Excel or Google Sheets, or tools like Open-Refine)
- Manual Competitor Monitoring (A viable option for small businesses, involving active monitoring of competitor activities on social media, websites, and other online channels)

6 Final Considerations and Future Work

This study aimed to identify and compile a set of best practices and recommendations to support small and medium-sized enterprises (SMEs) in their digital transformation journey and the adoption of Industry 4.0 practices. A systematic mapping was conducted to establish a theoretical foundation, complemented by interviews with SMEs in the food sector located in the central region of São Paulo city. The interview results underscore the urgent need to overcome perceived barriers to digital transformation in these companies.

Insights obtained from food sector SMEs reveal a general awareness of the need for digital transformation, although barriers such as cost, lack of knowledge, fear, and time constraints lead to hesitation. This resistance, often referred to as "decision-maker myopia," is common among SMEs, as noted by Fassini [11] in his analysis of challenges in technology adoption. The low adoption of automated customer service tools and digital platforms highlights a gap in implementing solutions that could enhance operational efficiency and customer experience, corroborating the findings of Vrontis et al. [12].

Although 50% of the interviewed companies already have some automated processes, challenges remain in automation and digital integration. This reinforces the need for investment in IT consultancy services and the development of metrics to evaluate the return on technology investment. The growing interest in innovation and technology adoption, including QR codes and process automation, indicates a favorable environment for implementing more advanced digital solutions. Fassini [11] suggests that market competition also plays a significant role in driving SMEs toward innovation, as companies feel compelled to adopt new technologies when their competitors and suppliers do so.

After understanding the relationship between SMEs and Industry 4.0, a set of recommendations was elicited to assist food sector SMEs seeking to promote digital transformation in their business models, resulting in the creation of a recommendation guide. By focusing on a specific sector and geographic

location, the study was able to generate tailored suggestions more applicable to companies in the food industry. However, since digital maturity challenges are widespread among SMEs, the recommendations may not be universally valid for other sectors.

As future work, it is suggested that the proposed recommendation guide be validated by ICT specialists and experts in technology adoption in companies to assess its technological contribution, and by managers of SMEs in the food sector to evaluate the clarity of the recommendations. After this validation, the guide should be shared and distributed to SMEs in the food sector, specifically those operating in food courts. Another suggestion for future work is to include the use of artificial intelligence as a recommendation for enhancing processes and providing insights to SME managers. Additionally, the guide could be expanded to serve other sectors of the food industry, increasing its applicability.

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