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RESEARCH ARTICLE

SMART LOGISTICS SOLUTIONS FOR REDUCING FOOD WASTE: A CASE OF D NIPAH CATERING

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ABSTRACT - The food and beverage (F&B) business is faced with a huge challenge in the form of food waste, which has a negative impact on profitability, sustainability, and environmental conservation. In recent years, smart logistical solutions have emerged as a potentially successful strategy for addressing the critical problem of food waste in the F&B industry. This article presents an overview of the application of smart logistics in the context of reducing food waste. The paper has a specific focus on the integration of technologies related to the Internet of Things (IoT) and production planning strategies. It investigated the concept of smart logistics and its benefits to improve decision-making, enhance visibility, and optimise the procedures involved in supply chain management. The study also underlined the role played by IoT in providing real-time monitoring, data collecting, and analysis, all of which can help in identifying and reducing concerns related to food waste. Qualitative methodologies involving the 5-whys analysis were used in this study to identify the root cause of the problem. Additionally, the present study highlights the significance of efficient production planning in reducing the amount of goods that are produced in excess, improving inventory management, and ensuring that production is in line with consumer demand. The findings also highlight the significance of combining the IoT technology and production planning in small and medium-sized enterprises (SMEs) to improve the efficiency and efficacy of their efforts to reduce food waste.

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1.0 INTRODUCTION

Food waste is a critical global issue with massive consequences across every aspect of humanity, including the economy, society, and the environment. According to the Food and Agriculture Organisation around one-third of the food produced for human use is lost or wasted yearly (FAO, 2019). Several potential solutions, including optimising the food supply chain and reducing waste, have been offered in response to this food waste issue. Many small and medium-sized firms (SMEs) operating in the food industry struggle to manage food waste effectively, resulting in significant losses in money and negatively impacting the environment. Overproduction, poor inventory management, and a lack of adequate employee training on properly handling and storing food are the primary contributors to food waste in SMEs (Dora et al., 2020).

In Malaysia, SMEs primarily operate in the food and beverage (F&B) sector. The SME Directory reported 767 registered businesses in the F&B industry (Malaysian SME Directory, 2022). Small and medium-sized businesses face various challenges, the most common of which are restricted access to funding, a lack of experience in business management, and trouble competing with larger businesses. SMEs can play an important part in the food sector by producing, processing, distributing, and selling food products. On the other hand, SMEs usually fail because they often have poor business strategy, insufficient planning, inappropriate inventory management, and weak management.

Smart logistics refers to the efficient organisation, planning, control, and execution of the movement of goods. This happens through data, traffic structuring, and navigation to achieve the highest possible level of productivity within the transportation system (Chang et al., 2020). In recent years, the concept of smart logistics has emerged as a potentially successful solution to address these difficulties and reduce food waste in SMEs (Kusumowardani et al., 2022). Unfortunately, upon closer inspection, it became clear that D Nipah Catering does not make use of any smartly applied logistics. This is one of the reasons why the catering company is experiencing food waste problems, ultimately causing financial issues. It is made worse by the fact that the majority of workers in the family business are members of the same family and possess no professional or relevant skills aside from receiving a lack of training. This circumstance resulted in decreased production as well as decreased sales. Because they are all soft skills and intangibles, SMEs typically fail to understand the significance of effective management. Hence, there is a significant need to educate SMEs about operation management and the ways in which effective management of an operation can improve their performance in areas such as productivity and sales. SMEs must also be made aware of the importance of operation management (Burggräf et al., 2022).

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Smart logistics is a prominent solution to the serious issues concerning food waste. The loss and waste of food is a huge problem that affects societies, economies, and environments on a global scale. Not only does it waste important resources, it also contributes to the emission of greenhouse gases, destruction of forests, and water contamination (Garske et al., 2020). The best way to successfully address the food waste problem is by applying smart logistics to improve the sustainability and efficiency of the food system. Businesses are able to minimise food waste, conserve resources, reduce their impact on the environment, and contribute to the growth of a circular economy when they put smart logistics practices into action (Massaro et al., 2021). Addressing the food waste issue aligns with the Sustainable Development Goals established by the United Nations, specifically Goal 12: Responsible Production and Consumption. It is essential to ensure sustainable consumption and production patterns to maintain the standard of living for both the current generation and the generations to come, which is the focus of Goal 12. Encouraging new methods, promoting best practices, and making a good influence on the environment, economy, and society are all things that may be accomplished by emphasising the significance of smart logistics in the reduction of food waste.

There is a need for comprehensive studies that investigate the specific obstacles and opportunities of implementing smart logistics solutions at various stages of the food supply chain. This requirement is one of the research gaps in smart logistics, which aims to reduce the amount of wasted food. While there is already published research on smart logistics and the reduction of food waste, not many studies have investigated how to effectively incorporate smart logistics solutions into the processes of food procurement, storage, and distribution. A review of further directions for artificial intelligence, machine learning, and deep learning in smart logistics by Woschank, Rauch, and Zsifkovits (2020) is one of the earlier studies on smart logistics. In addition, there is a gap in research about understanding the scalability and applicability of smart logistics solutions for reducing food waste across different types and sizes of food enterprises. Addressing these research gaps will contribute to a more thorough knowledge of how smart logistics may effectively reduce food waste, give useful insights for businesses and authorities, and lead the creation of specific strategies for diverse parts of the food industry. A study of this nature could help close the knowledge gap that currently exists in the field and increase the knowledge of how smart logistics can be one of the solutions to the problem of excessive food waste in the F&B industry.

Therefore, this study aims to investigate the use of smart logistics practices and their influence on the F&B industry by addressing the research gap previously discovered in the existing literature. The investigation was guided by two research questions: (1) How can smart logistics technologies and systems be effectively used to reduce food waste in the food and beverage industry? and (2) How can this be accomplished? The purpose of this study was to better understand smart logistics solutions to reduce food waste at D Nipah Catering. The first objective was to explore food waste issues at D Nipah Catering. Identifying the underlying causes helps in creating efficient solutions and actions to deal with the issue. The second objective was to analyse D Nipah Catering's current logistics practices and food waste. Such knowledge can be used to identify circumstances in which weak logistics procedures may be causing food waste. The third objective was to improve the smart logistics solutions to reduce the food waste issue at D Nipah Catering. By leveraging these solutions, the company can successfully minimise food waste, operate more effectively, and save money while promoting sustainable practices throughout its operations.

This paper consists of several sections. Following a thorough review of the literature, this study began by explaining the steps in the application process. The 5-Whys analysis and results provided by the company were then summarised in the results section. It is followed by an explanation of the implications and offering suggestions for the company to consider incorporating smart logistics into its supply chain. The final section presents a discussion of the findings in line with the research objectives, followed by a conclusion of this study.

2.0 LITERATURE REVIEW

2.1 Company Case

D Nipah Catering is a business focusing on the food and beverage sector. In addition to providing catering services, the SME also runs a restaurant known as Warong Kaklong in Cheras, Selangor, which serves a variety of breakfast and lunch dishes. The company was established by the current owner, Puan Roziah, in 2004 and has been in operation for nearly 20 years. The decision was prompted by her interest in cooking and managing a business. Two of her children, Hafizi and Hidayah, are helping her with the company's day-to-day operations. The restaurant is open from Tuesday to Sunday between 6 a.m. to 3 p.m. The company receives catering demands from customers daily, particularly for weddings, birthday celebrations, and other events on weekends and public holidays. Some of the popular menus at the restaurant include *nasi lemak* and *lontong* for breakfast, *laksa* and *nasi ayam* for lunch, and an array of 45 types of traditional Malaysian cuisines served for lunch.

The company began its operation at the first shop lot, where food was prepared and served to the customers, within the same area as the kitchen. In 2017, D Nipah Catering purchased a second shop lot to divide the premise into two sections: one is used for cooking and holding their inventory while the other is used to house the customers. The larger space area helps the company optimise its workflow and can divide the workstations into regions for preparation, cooking, and other activities. Since the first day of operation, the restaurant has never failed to draw a sizable crowd. Their annual sales have increased, and the overall market is responding positively to their presence. D Nipah Catering is well-known

for the quality of its food and has been featured in several publications, such as newspapers and television programs like Malaysia Hari Ini. They recently gained growing attention on Instagram because of their Nasi Lemak 50 Cent dish.

2.2 Issue of the Case

D Nipah Catering frequently experiences issues with food loss due to its inability to implement smart logistics. Waste products, including fruit rinds, bones, and other by-products, are unavoidable in the cooking process. Furthermore, the ingredients used in cooking, such as fresh vegetables, often do not have a long shelf life. These issues frequently lead the company to experience financial challenges. Other issues include the overproduction of food and, although it is occasional, food produced of poor quality. These issues resulted in an abundance of food waste that could not be sold to the customers at the end of their operating hours. They also do not have any options other than to discard the food. Another factor is the leftover by customers. According to Puan Roziah, most of the waste originated during the cooking process, where it takes two plastic bags daily to contain the food waste generated during preparation.

Food is thrown, and the company has suffered a direct loss of revenue. This covers the expense of purchasing supplies, ingredients, and raw materials that are eventually thrown away. Furthermore, other costs are related to the labour, energy, and other resources required to create the wasted food. To solve these problems, the company must consider incorporating smart logistics into their daily operations that can cut costs, improve efficiency throughout the supply chain, and earn additional benefits for the business. In the F&B industry, implementing smart logistics solutions can reduce food waste by improving supply chain operations and operational efficiency. This is particularly relevant for SMEs.

2.3 Food Waste in the F&B Industry

Waste is defined as intentionally disposing of goods or raw materials that are still usable but undesirable (Crittenden and Kolaczkowski, 1995). The straightforward definition of food waste is everything that is not eventually consumed by humans and is thrown or recycled, such as plate waste (i.e., food that has been provided but not eaten), spoiled food, or peels and rinds that are regarded inedible. In the F&B sector, the term "food waste" refers to the loss or discard of edible food at various points throughout the supply chain, including during manufacturing, processing, distribution, and consumption (Kasavan et al., 2022). It includes food thrown out due to overproduction, poor quality standards, consumer conduct, and food spoiled, damaged, or expired.

Food waste in the F&B industry draws attention to the inefficiency and wastefulness in utilising resources, such as food, water, energy, and land. It shows a gap between the production of food and consumption, which results in substantial negative effects on the economy, environment, and society. One of the significant contributors to food waste on a global scale is the F&B industry, which can be divided into three categories: avoidable, unavoidable, and possibly avoidable food waste (Bhajan et al., 2022). Food thrown away but could have been consumed at some point before its disposal is an example of avoidable waste. The term "unavoidable food waste" refers to the portion of food that is typically thrown away rather than being consumed, such as watermelon rinds and chicken bones. Whereas, food that is consumed in certain circumstances but not in others, such as potato peels, is an example of food waste that is possibly avoidable.

Food waste control can either save money or earn money (van der Werf et al., 2021). Most businesses see a good return on investment from efforts to reduce food waste. Doing so allows them to save money and produce less waste by purchasing only the amount of food they will consume. By reducing the amount of good food that is thrown away, businesses can save money on both the energy and worker expenses. Minimising the amount of food thrown out also helps the environment by saving the resources used. Throwing out food will result in the loss of other resources, such as the land, water, energy, and labour used in the food's growing, storage, processing, distribution, and preparation.

According to Jereme et al. (2016), the largest source of wasted food in Malaysia is private households, accounting for 38% of the total number, followed by food courts and restaurants (23%). As a result of the intense competition that exists within the food and beverage business, restaurant customers have come to expect larger portions of food to be supplied that go beyond the requirements of their food consumption. This has led to an unavoidable rise in the amount of edible food wasted when customers do not overeat the food served to them. The vast majority of uneaten food that is thrown away from restaurants is the result of customers leaving food on their plates after they have finished eating. If customers took more responsibility for their consumption habits, they might prevent the loss of 65% of wasted food. Consequently, the Malaysian F&B industry is the second largest contributor to the country's food waste.

2.4 Production Planning and Control

Production is the process by which values are created in the form of goods and services by transforming inputs into outputs or raw materials into finished goods (Drane & Faramarzi, 2019). During this process, values are created in the form of goods and services. All organisations engage in the process of producing goods and services in one way or another. Production Planning and Control (PPC) refers to a method used to design a chain of operations that helps manufacturers be in the right place at the right time. It enables them to maximise the effective use of available resources (Guise et al., 2023). Researchers have explored PPC as a field of expertise with many possible concepts and approaches. Having a thorough familiarity and understanding of PPC principles is extremely useful, particularly when these concepts are correctly applied in the operations. Large companies typically have a comprehensive understanding of the necessary PPC knowledge, awareness, and training, in addition to the talents required for the attempt. However, SMEs are still falling behind (Burggraf et al., 2022; Mishra, 2019).

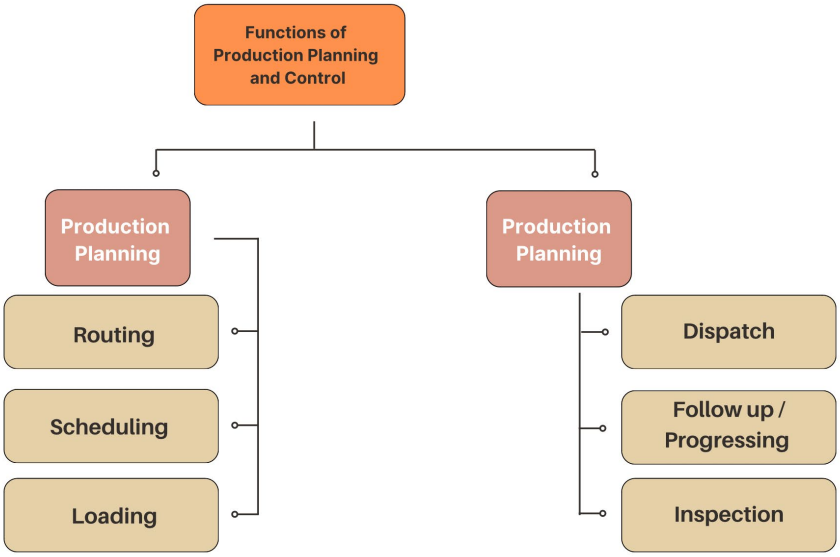

Figure 1. Functions of production planning and control

Figure 1 shows several roles and primary responsibilities of production planning and control. Production planning describes in detail how a corporation intends to make its goods and provide its services. PPC offers ideas that are applicable from the beginning of operations until the end, from the exterior scope to the internal, and from top to bottom. It involves careful oversight and coordination of production activities to ensure that operations run smoothly, reduce waste as much as possible, and efficiently use available resources. PPC also necessitates making predictions on the level of demand, creating production schedules, monitoring production processes, and modifying plans as required to meet production targets (Oluyisola et al., 2022). Along the whole food supply chain, proper planning and control of production are essential components in avoiding food waste. In this regard, PPC helps to decrease overproduction by accurately predicting demand and aligning production quantities appropriately, hence minimising the risk of unsold or wasted food. This can be accomplished by precisely forecasting demand and aligning production quantities accordingly.

2.5 Smart Logistics

Smart logistics refers to the use of modern technologies and methods driven by data to optimise and improve various processes involved in the management of logistics and supply chains (Nozari et al., 2021). In logistics, smart logistics describes integrating digital technology, automation, real-time data monitoring, and analytics to improve operational efficacy, visibility, and decision-making. The term "smart logistics" refers to a distribution network system for logistics that incorporates informatisation, intelligence, and systematisation by using the technologies behind the Internet of Things (IoT) and information technology. The logistics distribution system mainly relies on high-tech and modern management practices to reach high and low-efficiency levels.

Smart logistics typically includes features and capabilities such as perception, optimal decision-making, and intelligent feedback (Miao, 2018). It entails using digital systems, automation, real-time data monitoring, and analytics to improve supply chain efficacy, visibility, and decision-making. Real-time connectivity, seamless communication, and the ability to make accurate predictions are all made possible by smart logistics, which is enabled by harnessing the power of various technologies such as IoT, artificial intelligence (AI), machine learning, and cloud computing. It incorporates a number of different areas, including demand forecasting, inventory management, transportation optimisation, warehouse automation, and last-mile delivery. The use of technology-enabled solutions is the primary foundation of the concept of smart logistics with the goals of improving operational efficiency, lowering costs, increasing consumer satisfaction, and driving sustainability in the logistics and supply chain domain.

The ecosystem of the supply chain as a whole, in addition to individual firms, may gain several benefits from smart logistics. Primarily, it enhances operational efficiency by improving procedures, automating repetitive operations, and increasing the utilisation of available resources. This ultimately results in shorter lead times, better production, and cost reductions. Second, smart logistics improves visibility and traceability throughout the supply chain by giving real-time insights into inventory levels, transportation status, and orders that have been fulfilled (Ullah et al., 2023). As a result of this visibility, proactive decision-making, timely interventions, and improved customer service are all possible. In addition, smart logistics makes data-driven analytics and predictive capabilities possible. These capabilities make it possible to improve demand forecasts, inventory planning, and route optimisation. It also helps make delivery faster and more reliable by lowering the amount of time spent waiting around, streamlining routes, and maximising efficiency.

Today, businesses that practise smart logistics have greater access to vast amounts of information than ever before. This is possible due to the development of technology, which in turn paved the way for additional technological progress, ultimately allowing the logistics industry to grow (Kauf, 2019). The next step in the development of smart logistics is the

discovery of the incorporation of international trade with intelligent technologies. The efficiency of warehousing and transportation can be improved through several different ways. The utilisation of IoT and cloud computing facilitates the efforts to guarantee accuracy and accomplish improved monitoring, thus offering outstanding service to buyers.

2.6 IoT-Based Monitoring Systems Adoption

The Internet of Things (IoT) refers to the application of interconnected devices, sensors, and data analytics in optimising and improving various areas of logistical operations. In smart logistics, IoT makes it possible to gather, analyse, and use data in real-time, improving operational effectiveness, visibility, and decision-making throughout the supply chain. In recent years, IoT has emerged as a new technology that significantly changes how humans live their lives and their jobs. The use of such recent technology will ensure a smooth handling process and mutual benefits for all parties involved (Song et al., 2023).

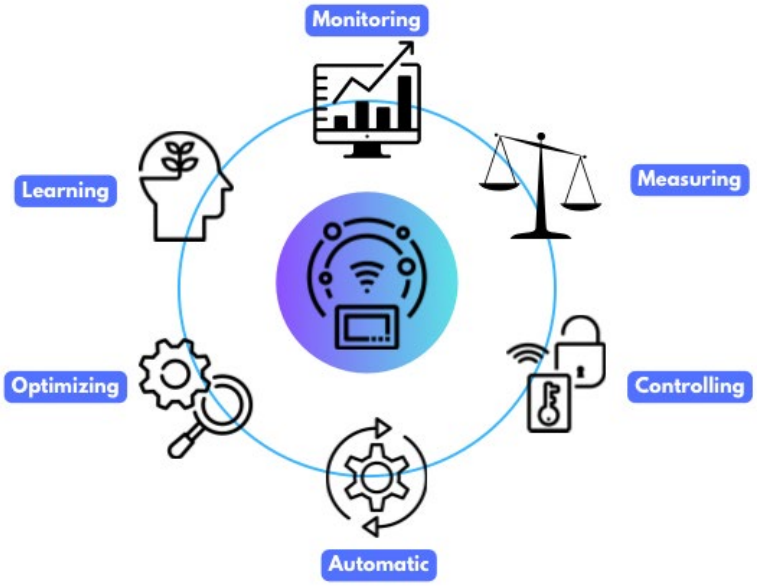

Figure 2. IoT-compatible features

IoT in logistics operations promises a significant impact, as demonstrated in Figure 2. IoT can monitor the status of various assets, parcels, and people throughout the value chain. The technology can also monitor the performance of these assets and change what they are doing at the moment and what they will do in the future. IoT also has the ability to automate business operations, which can remove the need for manual interventions, boost quality and predictability, and save costs. It can optimise how people, systems, and assets operate together and coordinate the activities of those involved. Finally, IoT can apply analytics across the entirety of the value chain to find greater possibilities for improvement as well as best practices.

Several researchers have advocated IoT as a concept that can help reduce food waste by utilising interconnected devices and sensors to monitor, track, and optimise different components of the food supply chain. IoT-enabled solutions give better visibility and control by gathering real-time data on factors such as temperature, humidity, location, and quality. This enables users to take preventative measures to reduce the amount of food that is wasted. Past research indicated that IoT is responsible for a 40% reduction in food waste due to improper temperature monitoring (Carlos, 2022). These technologies enable enhanced inventory management, efficient transportation, optimised storage conditions, precise demand forecasting, and customer involvement to reduce food waste at every stage of the food journey.

3.0 METHODS

This study was conducted by employing the qualitative research design involving interviews as the data collection method. Puan Roziah, the current owner of D Nipah Catering, was the focus of the interview. The study began by contacting the company and obtaining consent to conduct the research. A meeting was then scheduled with the owner. Before the interview, the researchers researched difficulties surrounding smart logistics and food waste in the F&B industry. An interview guide was also prepared, which outlined essential issues and questions relevant to installing smart logistics solutions and their influence on reducing food waste. The authors prepared several questions about the company. A physical copy of these questions was supplied to Puan Roziah before the interview to facilitate her understanding and preparation, hence enabling the gathering of complete and holistic data. The interview session was audio-recorded with the informant's consent. The interview aimed to elicit Puan Roziah's experiences, difficulties, and achievements in using smart logistics techniques and technology. Open-ended questions were used to encourage extensive and in-depth discussion, while follow-up questions were used to further investigate particular areas of interest. Such a strategy enabled the researchers to gather more accurate and detailed information about the actual deployment of smart logistics solutions

for decreasing food waste in the F&B industry. The 5-whys analysis was one of the qualitative techniques applied during the interview. The goal was to identify cause and effect connections, which will lead to the discovery of future process and project improvement opportunities (Boogaard, 2021). Additionally, the interview was conducted in a comfortable and exclusive environment for the informant to share her in-depth insights regarding the subject matter.

The interview session lasted for a total of 1 hour and 20 minutes. The informant provided enormous information, including the workflow and the proportion of daily resources wasted. The audio recording of the interview was transcribed verbatim to be used for further analysis. The researchers began with the data cleaning process by removing unrelated observations that had no influence on the analysis. The cleaned data was later analysed using thematic analysis to identify emerging themes and subthemes.

4.0 RESULTS AND DISCUSSION

4.1 Challenges Implementing Smart Logistics to Solve Food Waste Problem

The results found that D Nipah Catering faced numerous challenges concerning the lack of implementation of smart logistics, which is the root cause of the food waste problem. The company was not fully aware of the root cause of the problem and what constitutes smart logistics in its simplest state. This is understandable because the company's owner, Puan Roziah, began her professional life with nothing more than a hobby and a desire. This means that she did not have extensive knowledge regarding supply chains. Even though both of her children are helping her business, neither of them possesses any relevant or professional skills. Therefore, it is not surprising that they have no awareness of the problems that are occurring. The term "smart logistics" refers to the implementation of sophisticated technology, data analytics, and automation in the supply chain to optimise and streamline various processes. The company is currently dealing with the issue of food waste, which may be reduced if they adopt smart logistic practices.

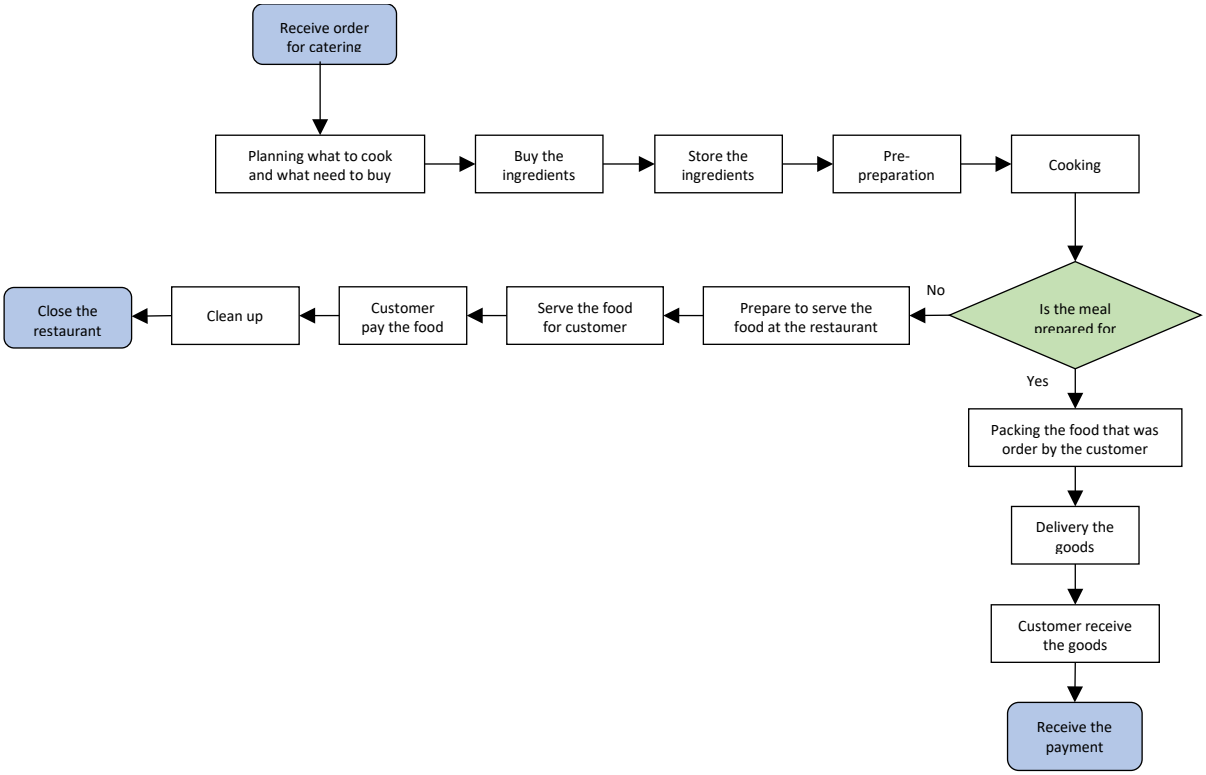

Figure 3. Overview of the workflow at D Nipah Catering

During the interview, the informant presented the workflow depicted in Figure 3 to better understand how their supply chain works. Several factors that contributed to the problem were identified as they explained the workflow in greater depth. It began with the planning process, which did not go into deep details, such as the amount of food to be cooked or served at the restaurant. The lack of good planning causes overproduction during the cooking process, resulting in food leftover. Their solution to this conflict is to either dispose of the leftover or give it to the workers gratis. In the field of F&B manufacturing, poor planning may result in excess production. It is often difficult for D Nipah Catering to forecast the demand from their customers precisely, which can lead to either an underproduction or overproduction of meals, depending on the circumstances.

Another contributor to the food waste issue is how the ingredients are stored. Improper storage can significantly cause food waste in the F&B industry as it can result in the rotting, expiration, and degradation of ingredients, ultimately prompting increased expenses. For instance, storing fresh ingredients like meat, vegetables, and fruit in inappropriate temperature regulation can accelerate their degradation, which in turn leads to spoiling and a shorter shelf life. It can also

decrease the food quality because improper storage can cause food to get stale. Not only that, but issues at the pre-preparation stage also prompt such difficulty. In some cases, cooking food ahead of time can be a factor in the unavoidable loss of food that occurs in the restaurant sector. When preparing dishes using meat or seafood, any bones and shells will end up as garbage. This is because these inedible components are often not served to customers, resulting in waste that cannot be avoided.

The catering service did not cause many of the food waste problems faced by D Nipah Catering but rather were caused by the restaurant. This particularly involved the leftover of unfinished food by the customers. The fact that the issue stems from customers themselves indicates that the company has lost all control over the cause of this problem. The data provided by the company stands as clear evidence that the catering and restaurant areas contributed significantly less to the overall amount of food that was thrown away than the kitchen.

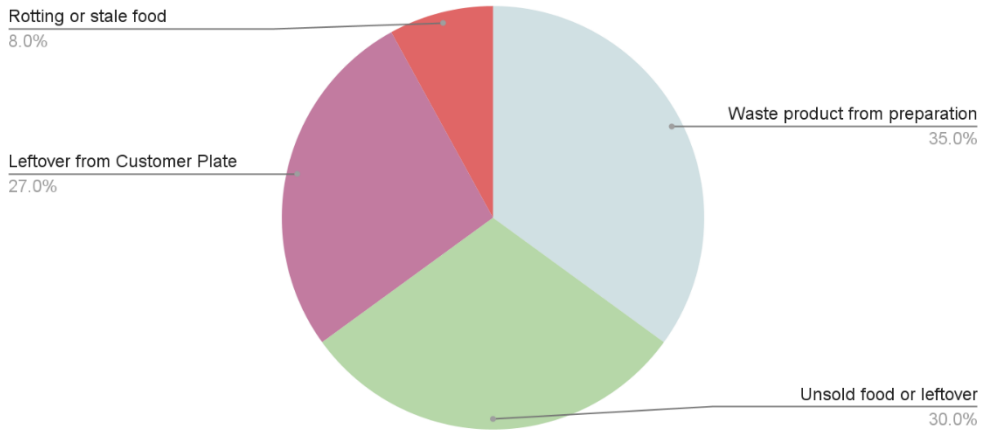

Figure 4. Daily resources of food waste

Figure 4 shows information regarding the daily resources of food waste, which the company owner provided during the interview. The first category is rotting or stale food, which represents food that is already cooked but unfortunately cannot be eaten due to its poor quality or deemed unsafe for customers to consume because it contains potentially harmful ingredients. The second category consists of uneaten food that is left on a patron's plate. The self-service nature of D Nipah Catering often prompts customers to take food in large quantities, resulting in food waste. The third category is discarded food from the preparation process. Food waste will inevitably be produced during preparation as a natural and unavoidable by-product of the cooking process, such as fruit rinds and bones. The final category is unsold food, which is not consumed. This commonly occurs when there is excess food production, which ends up not getting sold.

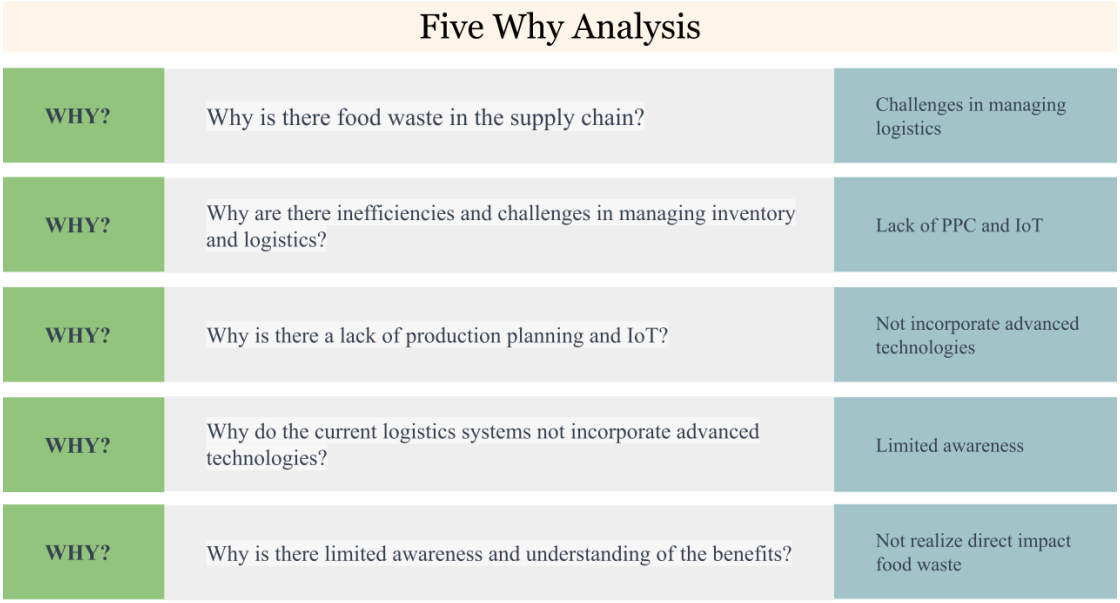

Figure 5. The 5-Whys analysis of food waste problem in D Nipah Catering

Figure 5 shows the 5-Why analysis, which was utilised to delve into the bottom of the issue faced by D Nipah Catering. The findings showed that one of the reasons causing food waste issues in the supply chain is inefficiencies and difficulties in inventory management and logistics. The basic cause of such a problem is insufficient production planning and management and the application of the IoT technology to streamline business processes better and cut down on waste.

Further investigation was conducted to identify the reasons behind the absence of production planning and control, along with the implications of IoT. The results clearly denoted that the existing logistics systems did not contain any cutting-edge technologies for the collecting and examination of data. Another inquiry was posed to gain an understanding of the reason why the existing logistics systems did not embrace innovative technologies. This is caused by the lack of information and comprehension regarding the possible advantages and the financial implications of adopting smart logistics solutions. The final why question was designed to uncover the reasons for the limited awareness and understanding of the benefits. It is possible that businesses do not recognise the direct influence of food waste on their financial performance, which can include the costs associated with purchasing, storing, and disposing of wasted food and lost revenue from products that were either unsold or went bad. The findings of this investigation revealed that the primary source of the food waste problem experienced by D Nipah Catering is the lack of information regarding the financial effects of food waste. This underlines the necessity for businesses to minimise food waste through innovative logistics solutions as it can lead to significant cost savings, greater operational efficiency, and enhanced profitability.

4.2 Suggestions & Implications of Implementing Smart Logistics for Food Waste Solution

The implementation of smart logistics solutions to resolve food waste may offer numerous implications for businesses and the food sector as a whole. There are various approaches that D Nipah Catering can take to lessen the amount of food wasted. First, it is essential to determine the fundamentals, which in this case means production planning. When conducting the planning process, it is essential to go into further depth and detail to understand the customers' behaviour and how it relates to the elements. D Nipah Catering can reduce the likelihood of excess production through the application of smart logistics solutions. It will allow the company to obtain real-time data regarding customer behaviour, order patterns, and inventory levels using technologies such as data analytics and predictive modelling enabled by smart logistics systems. Such data can be used to enhance demand forecasting, improve production planning, and modify inventory levels.

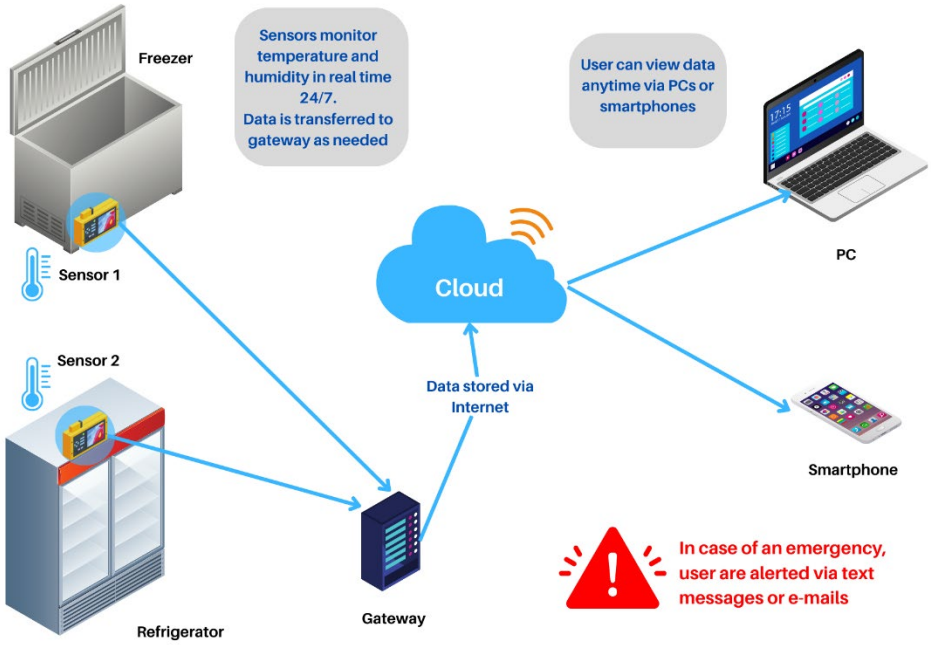

Figure 6. How IoT temperature sensors function

Figure 6 illustrates the operation of IoT temperature sensors and how they facilitate work, particularly in the F&B sector. With the implementation of smart logistics solutions, F&B businesses, including D Nipah Catering, can reduce the risk of improper storage of ingredients. The utilisation of IoT temperature sensors enables real-time monitoring of storage conditions, which in turn helps to guarantee that the temperature of the components is kept within acceptable parameters (Lutz et al., 2022). This will prevent food from going bad and avoid bacterial growth and contamination, improving the meal's safety and helps the company to avoid food wastage. They can also utilise smartphones or personal computers to monitor the temperature and humidity of their equipment, receive warnings if anything strange occurs, obtain monthly data on the trends in temperature and humidity, and modify the settings based on the reports they receive. Businesses are able to keep a careful eye on the quality of their ingredients and ensure that they are properly stored and maintained during the storage process by using IoT temperature sensors. This adds to the overall quality of the finished food products and ensures that they are safe to consume.

Furthermore, F&B businesses can exercise precise control over the serving size during the pre-preparation stage. The use of an accurate amount of components can be ensured by implementing practises for portion control, which also reduces the probability of an excessive amount of food. This can be accomplished by utilising standardised recipes and measuring tools and hiring staff trained on proper portion amounts. D Nipah Catering can also manage its output by

reusing leftover materials in different recipes. This will be cost-effective by encouraging them to handle and prepare food in an efficient and attentive way. The company can also develop a strategy to deal with any unconsumed food. Leftovers occur when customers take food in large quantities. Employees of D Nipah Catering should encourage customers to bring home any leftovers and to give unconsumed food to the employees or those who are less fortunate.

Implementing smart logistics solutions for managing food waste involves careful planning and investments in technical infrastructure. Existing evidence suggests that food waste in the F&B industry has numerous major implications for the societal quality of life, revenue, and the environment. The successful deployment of smart logistics in the F&B industry may lead to a significant decrease in food waste, improvement in operational efficiency, cost savings, and greater sustainability. Businesses can contribute to a more sustainable and responsible food system by optimising their operations, reducing the amount of waste they generate, and using cutting-edge technologies and data-driven techniques.

5.0 CONCLUSION

The concept of smart logistics refers to the effective management of inventories, the enhancement of production planning and supply chain coordination, the development of optimal delivery routes, and the installation of monitoring systems that operate in real-time. Smart logistics solutions offer a significant amount of promise in reducing the amount of wasted food in the F&B industry. Businesses can improve their supply chain operations and reduce the amount of food waste produced at various stages by utilising the latest technologies, such as the Internet of Things (IoT), data analytics, and automation. It also promotes improvement in operational efficiency, cost savings, food safety, compliance with regulations, and data-driven decision-making. Businesses can reduce food waste due to overproduction, spoiling, and expiration by properly managing their inventories, precisely estimating customer demand, and simplifying their delivery procedures. Monitoring and warning systems that operate in real-time make it possible to take immediate action if storage conditions become adverse. It is beneficial not just to the business itself but also to other parties, such as the customer and the environment. Nevertheless, it is essential to acknowledge that putting smart logistics solutions into action calls for careful planning and investments in technology infrastructure. Companies must evaluate their unique requirements, implement suitable technology, and provide adequate training and system integration. Smart logistics has the potential to play a significant part in reducing food waste, promoting sustainability, and forming a food supply chain that is more effective and solid if it is implemented with the appropriate strategy and level of commitment.

To fulfil the primary goal of reducing food waste, it is recommended that D Nipah Catering apply smart logistics in their company. The findings of this study have successfully met the intended research objectives, demonstrating that intelligent logistics is indeed a prominent solution to the food waste issue. The F&B industry has a huge chance to generate positive change, improve operational performance, and contribute to a more sustainable future thanks to the use of smart logistics solutions to reduce food waste.

5.1 Limiitation and Recommendation

It is strongly suggested for D Nipah Catering to begin implementing smart logistics into its operations. Not only will it contribute to reducing food waste, but it also has the potential to improve the effectiveness of the supply chain. To ensure that food is prepared as per the customers' demand, it is best for D Nipah Catering to utilise efficient production planning and control methods, such as demand forecasting. This can help prevent the overproduction of food and reduce the amount of food waste. There is also an urgent need to investigate the possibility of implementing smart logistics solutions, such as IoT-based monitoring systems, real-time inventory management, and data analytics tools. These technologies can provide real-time insights into inventory levels, demand patterns, and expiration dates, subsequently enabling more accurate production planning and reducing the risk of overproduction and waste. Putting these suggestions into action will not only enable D Nipah Catering to reduce food waste but also boost operational efficiency, reduce expenses, and improve the overall sustainability of their business.

The goal of future research should be to investigate the short- and long-term effects of putting smart logistics solutions into place to reduce food waste. It is essential to evaluate the sustainability of these solutions across various F&B businesses and supply chains to determine whether they can be scaled. Another suggestion for future research is to conduct economic analysis to examine the financial consequences of using smart logistics solutions for food waste reduction. It will allow F&B businesses to evaluate their cost-effectiveness, return on investment (ROI), and possible cost savings. Exploring these areas can improve the present understanding of the effectiveness and consequences of smart logistics solutions for reducing food loss in the F&B business.

A substantial amount of time and money may be required to conduct an in-depth study on the application of smart logistics to rectify the issue of food waste. The way in which specific aspects of smart logistics can be explored may be restricted due to time limits, and it is possible that the study will not capture long-term trends or shifts that occur over time. Furthermore, the F&B sector is dynamic with, constantly shifting customer preferences, emerging trends, and developing technologies. The conclusion of this study is relevant at the time of research; however, as the F&B industry advances, they might become less appropriate or even outdated. This should stand as a limitation for future researchers to consider. Despite these restrictions, this study can still provide useful insights into the possible benefits and problems of applying smart logistics for food waste reduction in the F&B industry.

6.0 CONFLICT OF INTEREST

The author(s), as noted, certify that they have NO affiliations with or involvement in any organisation or agency with any financial interest (e.g., honoraria; participation in speakers' bureaus; membership, jobs, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (e.g., personal or professional relationships, affiliations, expertise or beliefs) in the subject matter or materials addressed in this manuscript.

7.0 AUTHOR CONTRIBUTIONS STATEMENT

Muhammad Hairie Hanis prepared the manuscript, including writing, data collection and analysis. Yudi Fernando provided the initial research idea, supervision, editing of the manuscript, and final submission. All authors read and approved the final manuscript.

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10.0 APPENDIX

Appendix 1: List of interview questions

NO.	QUESTION
1.	What part, in your opinion, do smart logostics solutions play in reducing food waste in the F&B sector?
2.	Do you currently use any smart logistics technoques or technologies?
3.	What are the main difficulties or barriers you have run into while putting smart logistics into practice to reduce food waste?
4.	How did you resolve or get through these difficulties?
5.	Couls you give a general summary of the current logistical procedures used by your company?
6.	How do they affect the amount of food waste they produce from your current logistics?
7.	What areas do you think they need the most work in order to make the most of smart logistics and further reduce food waste in the F&B sector?
8.	How does food waste get defined and measured in your company?
9.	What specific categories of food waste are you trying to minimise?
10.	Can you give your undestanding what smart logistics is?

Appendix 2: Interview protocol