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Adoption Of MES In Complying With The National Standard MS 1500:2009 In Malaysia

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ABSTRACT

Malaysia is a pioneering country in the food manufacturing industry, notably in the halal sector. In order to ensure the quality and safety of halal food, the Malaysian government introduced a strict standard that governs the production from raw material to the final product. The Malaysia Halal Food Standard, MS1500:2009, was designed as a global halal food quality system benchmark, as it is used to obtain halal food certification in Malaysia. Even though this standard has several advantages to customers, particularly in ensuring safety, with benefits in food quality, compliance with this standard forms a significant challenge to the manufacturers, especially in managing knowledge and process. The literature suggests that the manufacturing execution system (MES) has the potential to facilitate manufacturing processes and control. Yet, the application of the manufacturing execution system to halal food is still in its infant stage. Thus, this paper aims to provide a review of how this software can help Malaysian halal food manufacturers comply with the national standard and certification requirements.

Keywords: food and beverage industry; MES; technology transformation.

1. Introduction

Malaysia is one of the emerging countries with rapid economic growth and advanced manufacturing development (1). The halal food industry is one of the prestigious industries in Malaysia. It is well-known for its cultural diversity, which stems from its multicultural communities offering a diverse range of Asian-inspired food products. This sector makes a significant contribution to Malaysia's overall economy, estimated to account for 8.1% of GDP and generating RM56 billion in export revenue by 2025, up from RM30.6 billion in 2020 (2). The food manufacturing industry has several characteristics that other sectors do not have. It integrates all entities of the food supply chain. However, this vital sector faces several challenges, notably in planning, cost control, resource allocation, the complexity of production, and different food categories, necessitating vastly different production processes. Due to the complexity of food production chains, multiple halal issues, and halal certification fraud, Muslim customers are becoming more cautious about their food choices and decisions. The government has been continuously involved in halal certification, including establishing government

entities to regulate and protect the use of the halal logo for product labelling. Malaysia has set a unified standard for halal food that governs the whole country in this context. This standard is MS1500: 2009, a Halal Food guideline in Malaysia that regulates the manufacturing, processing, handling, and storage of halal food. It also serves as the foundation for halal certification implementation, with JAKIM and state religious authorities using it as the halal certification compliance requirements (3). The MS1500: 2009 standard received international recognition and has served as a global benchmark for other nations for many years, as well as assisting others in establishing their halal standards (4). Implementing this standard greatly benefits halal manufacturing, inspiring practitioners to embrace it due to its future potential. Even though there are these advantages, several challenges still impede the development of this industry. For example, due to a lack of awareness, ignorance, and grasp of halal requirements and import laws (5). The implementation of halal food standards in Malaysia is extremely difficult, and the halal food requirements are highly crucial to manufacturers, production companies, and distributors to ensure quality and safety. The national standard has seven critical requirements that must be met with a high level of compliance, which presents obstacles that frequently result in failed execution due to the stringent requirements provided by the department of standards. This industry is faced with challenges in data processing that harm production efficiency and productivity and require a high degree of traceability and transparency. These challenges lead to upgrading the technology in this industry. Whereby, when sustainable technology is applied, natural resources are minimized, waste is reduced, energy is saved, and operational and organizational procedures are improved (6). To mitigate these challenges, the application of the Manufacturing Execution System (MES) is important because it can assist in managing and analyzing real-time data in manufacturing processes in two ways. First, MES transfers production plans from enterprise-level systems to the production area in operational detail. Second, they provide critical key performance indicators for making business decisions and improving manufacturing performance, such as specific energy consumption and machine efficiency metrics. Despite the benefits of MES, understanding how to utilize it effectively is still a challenge. Thus, this paper aims to provide a review of how the application of MES can help Malaysian halal food manufacturers comply with the national standard and certification requirements.

2. Literature Review

2.1. The Malaysian halal food industry

Due to the cultural diversity, Malaysia's food sector is well recognized, which stems from multicultural communities that offer a diverse selection of Asian-inspired food products. So, Malaysia has been acknowledged as a halal hub, offering an example to other countries as a multicultural society that practices many religions (7). The halal products and services industry is one of Malaysia's most important economic contributors. It is estimated to contribute 8.1 % of Malaysia's GDP and produce RM56 billion in export revenue by 2025, up from RM30. 6 billion in 2020 (8). Malaysia's halal industry is worth approximately US$30 billion and is expected to grow by 25% over the next five years, while the global halal industry is worth about US$2.3 billion and is expected to grow even more (9,10). Malaysia was ranked 209.8 on the Halal Food Indicator (HFI) based on several influential factors such as halal food trade, regulations, public awareness, and product pricing (11). For food to be considered halal in Malaysia, principles, Islamic dietary practices, livestock slaughtering methods, and food storage, display, processing, hygiene, and sanitation must be followed. (4).

2.2 Manufacturing Characteristics of the Food Industry

The United States Bureau of Labor Statistics (BLS) defines food manufacturing as converting livestock and agricultural products into intermediate or final consumption products. The raw materials (usually of animal or vegetable origin) processed into food products define the industry groups. (12). A significant part of the BLS definition is the transformation of these authentic foods into new foods using equipment,

recipes, and food manufacturing techniques such as baking, fermenting, or chemical processes. The terms "food manufacturing" and "food production" are different in that the former refers to food items made with machinery and equipment. At the same time, the latter describes processes performed by home cooks in smaller quantities.

The food manufacturing industry has several characteristics that other sectors do not have: seasonal solid production, the short shelf life of finished products, quick inventory turnover, strict quality control, etc. Because of this feature, the food manufacturing industry has a varied demand market. The market serves as a benchmark for enterprise management; therefore, organizations that can handle market challenges well, have their qualities, and can successfully address these problems while also adjusting to market demand will win in the end. The manufacturing processes of the food industry also integrate the many entities of the food supply chain; it encompasses all players and activities, beginning with primary production and processing to food manufacturing, distribution, retail stores, and consumer consumption (13).

Since food manufacturing and processing involve complicated processes because of changes in origin, harvest seasons, and production process characteristics, even the same raw material will influence the product's stability. It is challenging to measure and evaluate each active component.

In addition to several challenges in planning, cost control, resource allocation, and the complexity of production, different food categories necessitate vastly different production processes. These challenges of the food manufacturing industry, according to (TriStar, 2021), can be summarised as follows: first, the product has a shorter shelf life-Food manufacturers must adhere to strict schedules, arrange for specialized storage, and transportation, and keep comprehensive inventory records. Second, the manufacturing environment has strict hygiene and food safety requirements, from equipment cleaning to stringent controls and potential allergens. Third, a highly regulated sector in which manufacturing practices must be compliant. And finally, the inclination toward price-sensitive items where every margin counts.

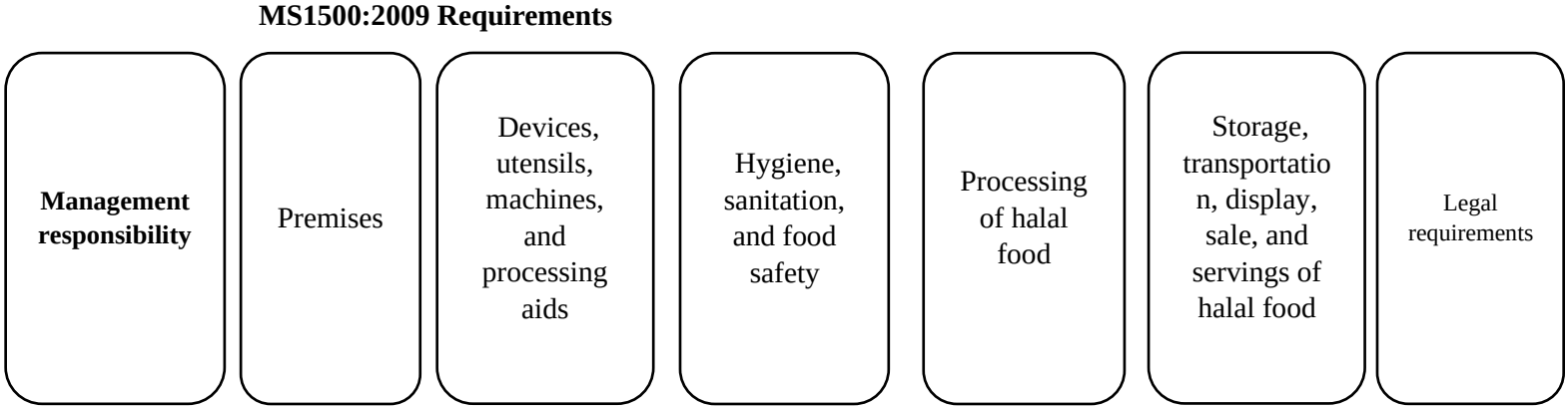
2.3 MS 1500: 2009-Halal Food standard in Malaysia

Due to the complexity of food production chains, multiple halal issues, and halal certification fraud, Muslim customers are becoming more cautious about their food choices and decisions. As a result, the Malaysian government devised ways to ensure the integrity of halal items. The Malaysian government has been continuously involved in halal certification, including establishing government entities as standard-setting and accreditation bodies and effectively protecting the use of the halal logo for product labelling. Furthermore, Malaysia has developed its halal laws, regulations, and standards, resulting in a unified standard for the entire country. This standard is set by committees comprised of manufacturers, policy-makers, consumers, and others with relevant interests who reach a consensus (14). Halal food Malaysia Standard MS1500: 2009 is a Halal Food guideline in Malaysia that regulates the manufacturing, processing, handling, and storage of halal food. MS1500:2004 is the first version of MS1500:2009, based on an earlier SIRIM standard called MS 1500: 2000. It is noteworthy that Malaysia's halal food standards, MS1500: 2004, have received international recognition and have served as a global benchmark for other nations for many years, as well as assisting others in establishing their halal standards (4).

This standard includes all the requirements of food Safety Principles (MS1514), Hazard Analysis Critical Control Point (HACCP-MS1480), as well as Good Hygienic Practice (GNP), and Sanitation Standard Operating Procedures (SOPs) (15). Also, it meets the halal requirement and meets worldwide benchmarks such as ISO 9000 and Codex Alimentarius. In addition to being comprehensive standards covering all aspects of halal food, this standard also serves as a new marketing concept and a quality benchmark (16). It also serves as the foundation for halal certification implementation, with JAKIM and states religious authorities using it as a reference to fulfil halal certification compliance requirements(3).

2.4 MS1500: 2009 Requirements

Halal food requirements are crucial to manufacturing, production companies, and distributors to ensure quality and safety and comply with Shariah law. Food enterprises should ensure compliance with halal food requirements in Muslim countries where the entire food manufacturing process, from raw ingredients to finished products, must adhere to Halal standards (17). MS1500: 2009 standard requirements are challenging to execute, presenting obstacles that frequently result in failed execution due to the stringent requirements provided by the department of standards. This section focuses on the requirements for food manufacturing, processing, handling, distribution, and preparation, as well as food safety and hygiene, as given by Malaysia's department of standards (18), which are represented as follows:



There are benefits of Halal standards owing to their future potential, which inspire practitioners to embrace them. Aside from hygiene, quality and product safety entices businesses to adopt Halal standards. Whereby Halal certification is the initial stage in capturing the position of the international Halal food market. In Malaysia. the halal food logo is widely recognized and well accepted by countries. According to (Azmi et al., 2018), accreditation of halal standards benefits market participants (19)(18)by ensuring the quality of final products, representing regulatory bodies' interests in areas such as safety and health, the environment, and other societal protection and performance requirements, and minimizing risks and ensuring reliability. However, with these advantages of halal standards, the complying faces several challenges: food manufacturers have not met halal standards due to a lack of awareness, ignorance, and grasp of halal requirements and import laws (5). So, industry participants must be aware of the requirements for developing products for Muslim markets, and importers must be aware of and adhere to the standards of Muslim-majority countries, which cover religious and food safety issues (20). It is worth noting that the MS1500:2009 guideline strongly recommended food manufacturers use appropriate detection or screening technologies during manufacturing and processing to help them comply with the requirement.

2.5 Technology challenges in the halal food industry in Malaysia

Globalization of the world economy, as well as related factors such as increasing production efficiency, shortening innovation cycles, and maintaining high quality, are constantly putting pressure on manufacturing companies; in this regard, IT tools are required to improve the efficiency of existing industrial processes (21). IT systems have been utilized to enhance manufacturing processes and are essential for manufacturing companies that want to remain competitive in the marketplace (22). In this context, Manufacturing processes on the shop floor should not be underestimated to capitalize

on development opportunities. The traditional operational IT systems such as (ERP) cannot respond in real-time to meet the needs of shop-floor changes due to growing process flexibility and product diversity (23). In Malaysia, food manufacturing and processing are crucial sectors, and they have continuously evolved and improved, allowing the country to become a net exporter of processed foods. However, these industries are faced with challenges in data processing that negatively impact production efficiency, productivity, and compliance with norms and regulations, which require a high degree of traceability and transparency.

2.5.1 Efficiency of manufacturing processes

In Malaysia, there is no appropriate sustainability assessment technique for measuring food manufacturing operations (24). Since the halal sectors in Malaysia are still running their operations on the shop floor in a traditional way, the manual documentation and calculations and stand-alone software systems were still in use (25). And this is a result of using conventional management strategies to operate food manufacturing operations, which will lead to low productivity and efficiency. Malaysia, for example, has a higher demand for fresh meat products but is facing production shortages, so the industry only meets around 28 to 30 per cent of domestic demand (Amna et al., 2018). Similarly, local milk production meets less than 10 per cent of domestic demand due to low productivity and a lack of technological adoption (Hamid, 2021).

2.5.2 traceability and transparency

Manufacturing Halal food necessitates a comprehensive understanding of the whole supply chain, especially now that Muslim customers are more concerned and want assurance that the food they consume is Halal and tayyib, which means healthy, clean, wholesome, nutritious, and good (26). And this is because of the many situations of contaminated Halal food, such as the mix of Halal and non-Halal food in storage, poultry, and meat slaughtering, which do not meet Shariah's requirements. In Malaysia, most of the previous research on halal food focused on the integrity of the Halal food supply chain as a growing concern. They recommended increasing transparency to enhance the halal food supply chain (27–29). So, each supply chain partner's integrity must be monitored. Furthermore, given the growing customer demand for a better Halal food supply chain, adopting a Halal traceability system should be considered(30). This is critical to reducing and ensuring that contamination does not occur throughout the processing of Halal food in a Shariah-compliant manner. Traceability can be used to track the Halal status of specific food products at every level of the supply chain, improving Halal transparency and enhancing Halal integrity.

Compliance with regulations and standards, on the other hand, requires a high degree of information gathering to ensure traceability and transparency, such as quality assurance standards and regulations in the food industry, which provide new challenges for production-oriented information technology (IT) systems. Whereby transparency and traceability were once only applicable to security-oriented systems, but they are now becoming increasingly important in other industries (Meyer, 2009).

These IT challenges lead to upgrading the technology in the food industry. Whereby, When sustainable technology is applied, the use of natural resources is minimized, waste is reduced, energy is saved, and operational and organizational procedures are improved. (6). This is shown by a recent ING report which indicated that technology aids food sectors in manufacturing more effectively to meet the demands of a growing global population (31).

2.6 Manufacturing execution system

MES stands for Manufacturing Execution System, and it is an information system that supports human activities in manufacturing operations management. The International Association of Manufacturing Execution Systems (MESA) defines MES as the ability to optimize the control of a product's entire manufacturing process through information transmission, from order release to product completion, to react and report on real-time shop floor activities, as well as guide

and optimize them accordingly with the data currently provided (32). MES is designed to support MOM activities, which are the various activities required to manage manufacturing operations on the shop floor, through comprehensive MOM data storage, a MOM communication hub, and the replacement of older separate systems and manual work as an integrated information system for MOM.

The MES links enterprise information integration and the essential components of implementing enterprise agile manufacturing strategy and achieving shop floor production agility. In the last ten years, MES has grown significantly worldwide, and it is now competing with production management technology and real-time information systems on the shop floor (33).

Plant Information Model according to MESA

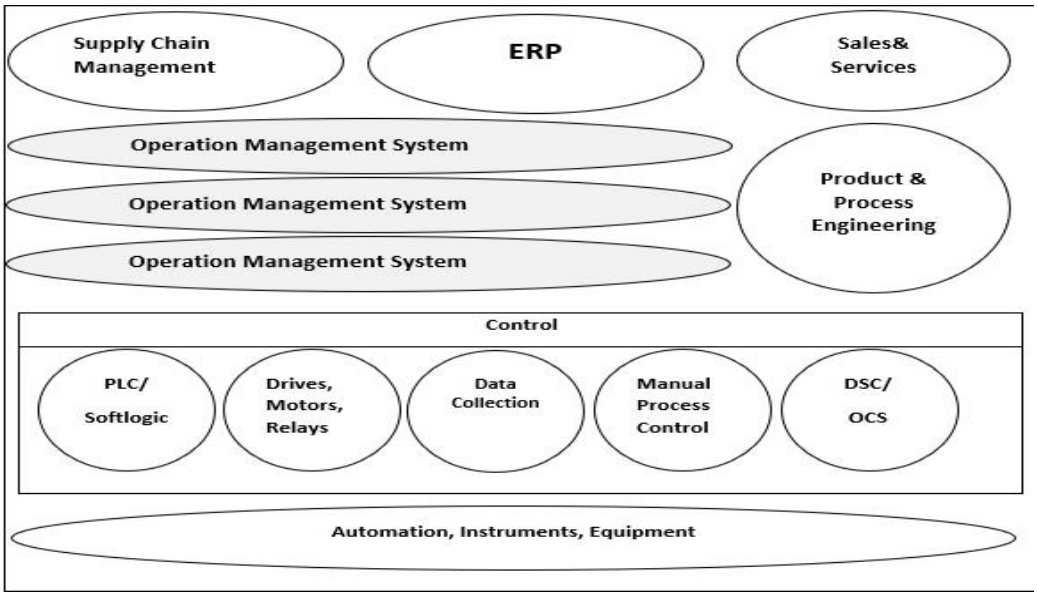


Figure 1 Before MES implementation

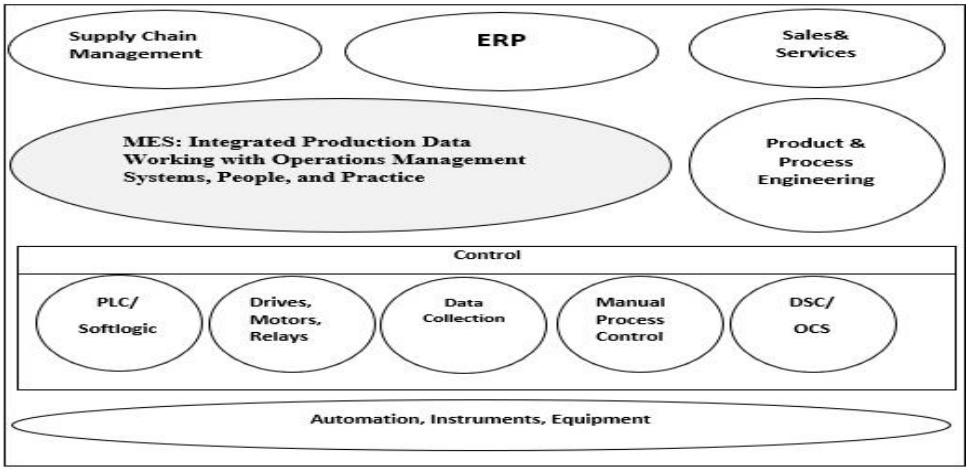


Figure 2 After MES implementation

According to the Manufacturing Enterprise Solutions Association (MESA), 11 MES core functions were developed to meet the needs of various manufacturing environments.

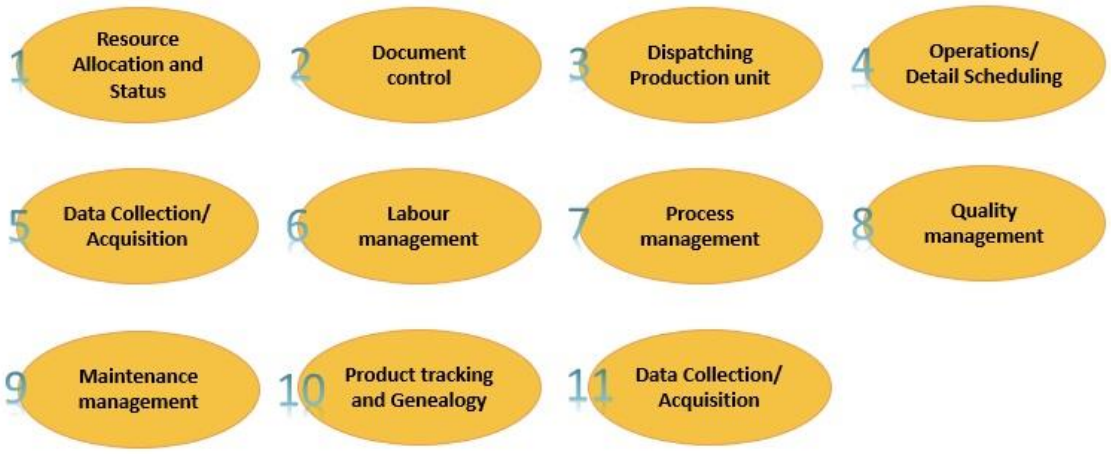


Figure 3: MES functions according to MESA international

3. Discussion and Finding

3.1 MES Solution for the Food Industry

As (Osaka, 2011) stated, the support of MES to the manufacturing process in the food and beverage industry can be as follows:

3.1.1 Production management

The MES support for production management begins with the management of production work orders and a package (filling) work orders that come from ERP and support for creating, modifying, freezing, and cancelling work orders. In this context, MES can achieve enterprise-wide informatization by integrating with ERP and other systems, as production should be scheduled based on capacity. It also distinguishes between finished products, semi-finished products, raw materials, and so on, which helps in forming a Bill of Materials (BOM)**.** MES also helps manage equipment, workstations, and production lines by pre-defending the production process route. Finally, MES will support the entire production execution process, including providing production instructions, production in strict accordance with the pre-defined production process route, ensuring the completion of the work order "quality and quantity," real-time control of the work order's status, and the ability to freeze problem work orders, as well as dashboards, reports, and Kanban to display the production status in real-time.

3.1.2 Material management

The main goal of an MES is to ensure effective execution of the manufacturing operations and improve production output. The MES collects data about material management and work in progress (WIP) and other plant activities as they occur. This data, in turn, allows decision-makers to understand the current settings of the factory floor and better optimize the production process. It enables to make wise decisions in raw material management, container, utensil management, and work-in-process identification. It also provides accurate data that helps to material execution such as material transfer, adjustment, scrap, rework, merge, disassemble, accept, ship, pull, material consumption, material production, rework and scrap control, work-in-process status management (freeze, isolate, release), finished products, semi-finished products, and the distinction of work in progress. MES also improves dashboard and report display such as

work-in-process and inventory status real-time monitor of the location of material batches. Finally, MES facilitates integration with other business systems such as material consumption.

3.1.3 Product tracking

Halal food manufacturing can gain advantages from MES by wisely utilizing its functions. For example, MES helps to improve product tracking/traceability and genealogy management. This can help Halal food manufacturers to track the use of man, machine, material, and method; it can be tracked based on multiple levels of Lot/Item/Unit, track anomalous processes such as rework/scrap, and it can track historical operation records of operators (manual control events). MES also can be utilized in the dashboard and report display such as forward tracking, backward tracking, and efficient relevance report. It can also be a crucial system that improves integration with other business systems, which helps trace production from raw materials until the final product.

3.1.4 Quality Management

MES plays a central role in improving quality control of the manufacturing process. This includes the management of product quality from the moment the material enters the production line until the final product is created. Specifically, the quality control shall be based on the design and process documentation and the requirements of the manufacturing quality control plan through: first, improving quality sampling and execution, which includes process control settings, process-based sampling rules, and plannable sampling rules, online and offline quality sampling, HACCP. Second, improve sampling management, including planned and unplanned, online or batch quality data collection, equipment status, early warning event data, and CAPA. Third, it upgrades the deviation management through monitoring data that deviates from the standard value and provides visual means to monitor real-time data. Support net content control such as controlling the weighing equipment, strictly following the information displayed on the label (weight, quantity, etc.), and QA release management (WIP freeze, release). Support the dashboard and report display such as one pass rate statistics key index (KPI) display. Finally, improving integration with other business systems such as download quality specifications and upload quality analysis data.

3.1.5 Manufacturing intelligence

Manufacturing execution systems are more critical than ever. The digital plant is based on data, and turning all that collected and aggregated data leads to business value, for instance, through better asset, inventory, and material tracking, gaining intelligence regarding manufacturing processes for better decision-making, managing performance, and quality, coordinating production activities and many evolutions which are still coming our way. Manufacturing execution systems are evolving information systems, and they changed as new technologies such as cloud computing, Big Data (analytics), and IoT (as we know it today in Industrial IoT) emerged. The primary purpose of manufacturing intelligence is to optimize production by utilizing advanced information and manufacturing technologies. The MES collects and acts on manufacturing data in real-time and performs critical data analysis to improve and regulate many aspects of the manufacturing process in the gap between automation systems and enterprise resource planning (ERP). This helps in releasing efficiency and optimizing the quality of processes and products, which reduces costs, speeds up production, traces genealogy, and improves quality. MES influences manufacturing intelligence through improving intelligent production, which includes production sequence, work order status, overall production capacity, and efficiency, OEE statistics, the efficiency of assembly lines and packaging lines, and planning/capacity balance. It also helps estimate the needed materials, which helps manage inventory management, scrap, and rework materials. Manufacturing intelligence improves the capability of tracking/tracing genealogy reports and forward/backward tracking. The Quality management evaluation is another aspect of intelligence manufacturing, including the quality analysis index, HACC, historical data analysis, and reports. Finally, it improves intelligent efficiency analysis such as OEE

statistics of packaging lines, downtime statistics, and OLAP points.

3.2 Analysis of MES demand in the food and beverage industry

The food and beverage industry often has a high degree of process, large production batches, complex processes, high precision in production management, high requirements for monitoring, management, and production analysis, diversified consumer markets, and ever-changing consumer markets. The Manufacturing Execution System (MES) maximized machine usage and production outputs as part of the digital transformation process. Production information history, order execution, and real-time tracking of production order dispatching are only some of the features and benefits of smart manufacturing for production with MES; meanwhile, no Integrated Management System (IMS) in place to integrate and share data with other systems (34). In the food manufacturing industry, the MES can bridge the information gap between the shop floor and control systems, can aid food and beverage manufacturers in improving process transparency, identifying options to enhance manufacturing efficiency and reduce energy consumption, and providing businesses with critical KPIs that allow them to make business decisions (35). Customer demand determines that in addition to strictly controlling quality and ensuring product safety and health, food/material manufacturers also need to reduce costs, increase product diversity, and shorten product listing time. Therefore, the demand points of MES in the food and beverage industry are: first, **Real-time data collection and analysis**. According to the enterprise's production equipment status, select a reasonable data collection method to achieve a seamless connection with the underlying automation equipment. Obtain product and process parameter information related to production equipment and production process and provide historical information, products, and process parameters. Provide batch management and tracking data, equipment and maintenance, quality management, and other modules. Second, **Production optimization and management**. Realize production scheduling and analysis, material management and control, cost accounting and control, etc., according to the production plan combined with equipment materials and other conditions to formulate the best production plan to meet the requirements of low cost and high efficiency. Third, **Production monitoring**. Supervise the production status, prepare for the products according to the current batch production status, equipment status, employee information, etc., to respond to various emergencies and make reschedules. Fourth, **Batch tracking.** Collect the production and operation data of the current batch (intermediate and final), including online parameter values and offline measurement values, evaluate production quality, and decide whether to continue production; when ERP questions the production status of a final batch, The recoil tracking will be conducted based on the records of this batch, and the results will be reported to the ERP. Finally, **Equipment management.** Guide the company to maintain equipment to ensure the smooth progress of production, produce periodic and preventive maintenance plans, and provide responses to emergency problems (alarms); keeping historical records of past events and issues is helpful to deal with cases that may arise.

4. Conclusion

This study addressed an important topic, the halal food industry, from various perspectives, particularly the importance of this industry at the local Malaysian and international levels. It also included a discussion about some of the challenges facing this industry, especially in production and compatibility with halal standards. To bridge the research gap in supporting the halal food industry according to high-quality standards, this paper presented a vision of how the implementation of the manufacturing executive system MES can bring new insight to the development Halal food industry.

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