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Utilization of Internet of Things on Food Supply Chains in Food Industry

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ABSTRACTS

This study aims to analyze the use of the Internet of Things (IoT) in supporting the management of food supply chains (FSCs) in the food industry. This research used qualitative research methods. The results obtained from this study are increasing the effectiveness and efficiency of the existing food supply chain in the food industry by applying the IoT concept to food supply chain management. These results can be obtained because the IoT concept is supported by various systems and technologies that can be implemented and developed so that IoT can help identify and deal with existing problems more quickly while being able to assist in the decision-making process with information obtained through IoT technology so that it will support development food supply chain management in the food industry. This study was conducted to see how much influence the internet of things (IoT) has on food supply chain management in the food industry.

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1. INTRODUCTION

At this time, technology is developing so fast. One form of technological development is the use and access of the internet, which is quite extensive in various fields. The enlarger of technology, especially the internet, is shown by the emergence of many concepts in its use. One of the concepts of using the internet is the Internet of Things (IoT). IoT is a system of interconnected devices, using sensors and internet connections to collect various data and information (Jones *et.al., 2018*). Then the main key for the use of the Internet of

Things in an industrial field is the concept of technology. If the food industry wants to apply intelligent management and automation to aspects of the supply chain, it is important to build a system that has good efficiency for the food industry based on the Internet of Things (Zhang *et.al., 2018*). The food industry is quite complex. In the Food industry, there are several industrial activities known as food supply chains (FSCs). Food supply chains are a major thing in the food industry because FSCs show the flow of the production process to distribution to consumers, which broadly includes the production, processing, distribution, retail, and consumer processes. The application of IoT in the food supply chain (FSC) is one of the promising applications. Because its applications cover precision agriculture to food production, processing, storage, distribution, and consumption, it presents a promising potential to overcome challenges especially, in terms of control.

Several studies have been researched on the internet of things for the food supply chain. A study about the internet of things solution for the food supply chain was conducted by Xiaorung, et al. In the study, it is stated that IoT will create safer, more efficient, and sustainable FSCs (Zhao *et.al., 2015*). This is in line with Jagtap & Rahimifard. They claimed that implementing IoT in the food supply chain will help provide high-level information and increase awareness about resource consumption across all actors in the food supply chain (Jagtap & Rahimifard, *2017*). A study about the impact of the internet of things on the supply chain was conducted by Mostafa, et al. In the study, it is stated that IoT is one of the important technologies in facing industry 4.0. IoT is considered as one of the greatest technology in improving performance and controlling capability in supply chain management (Mostofa *et.al., 2019*). Moreover, there is a study that shows the roles of food supply chain quality management by Ben-Daya, et al (Ben-Daya *et.al., 2020*). There is also another study that virtualizes food supply chains with the internet of things by Verdouw, et al. In that study, it is stated that virtualization can play an important role in meeting the specific challenges of the food supply chain, including dealing with perishable products, unpredictable supply variations, and food products that have strict safety and requirements (Verdouw *et.al., 2016*). Therefore, from these studies, we can see the role of technology is quite important, especially in supply chain management.

The purpose of this research is to identify, analyze, and depict the use or application of IoT in the food industry, particularly in the context of food supply chain management. The making of this paper is done by collecting various data and then analyzing the data, which will produce a result. The results of this analysis show an overview related to the management system in the food supply chain, which will indirectly show an increase in the effectiveness and efficiency of the food supply chain management system in the food industry with the application of IoT.

2. METHOD

The method used in this research is the descriptive quantitative method, the research method used is qualitative, namely research that is descriptive and tends to use analysis. This research

method aims to identify and describe the events experienced by the research subjects, such as perceptions, behavior, and actions, which describing in the form of words and language in a special context and using various methods carried out as a whole. The research was carried out in several steps, starting from data collection, data analysis that would produce a finding, which can be seen further in the image below. (See Fig.1).

Fig. 1. Method

Figure 1 shows that the author conducts research methods on "Utilization of the Internet of Things on Food Supply Chains in Food Industry" through:

a. The data and information collection method used in this article is a literature study. This literature study is used to obtain data and information relevant to the existing problems. Literature studies are carried out by reading, studying, reviewing literature in the form of journals, articles, and books on the internet related to topics and problems in research in articles. The theme raised in this article is related to the use of IoT in the food industry, especially in food supply chain management.

b. After obtaining the necessary data, data analysis was carried out, then the data were analyzed using the literature review method. This analytical method is used by systematically identifying the studies that have been obtained relating to the use of the Internet of Things for food supply chains, especially in the food industry.

c. The results of this analysis can identify the utilization or implementation of the Internet of Things in food supply chain management in the food industry.

3. RESULTS AND DISCUSSION

The food supply chain generally runs in several stages, starting from production, processing, distribution, retail, and consumers. However, in the food industry, the food supply chain is more focused on production, processing, and distribution.

A. Production

This stage of production is related to agriculture activities that exist on a farm. At the production or agriculture stage, several activities or operations in the agricultural sector can utilize IoT technology, such as irrigation control and pest control. At the production stage, there are also livestock sectors, such as smart poultry farms, which also need to be considered regarding the use of IoT in the food industry.

1. Irrigation Control

Irrigation is important in the agriculture stage. The net ratio of benefits to the entire agricultural sector water productivity in agriculture is defined. One of the keys to increasing water productivity in agriculture is to maximize irrigation scheduling, so agriculture can save water without affecting existing yields.

The IoT concept can be used to create Smart Irrigation. With Smart

Irrigation, workers can monitor irrigation and can turn on pumps without having to visit the plant location. The IoT concept can be done by utilizing an internet network for all sensors on agricultural land (Soil and Weather Sensors). Data related to .environment can be obtained and sent to workers through applications. A smart irrigation system can be seen further in the image below (See Fig 2).

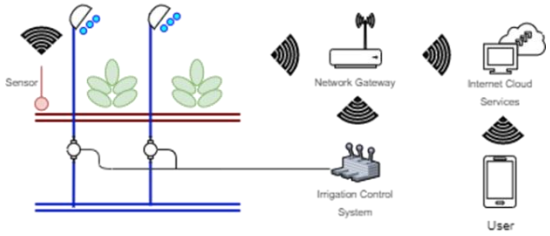

Fig. 2. Smart Irrigation System

Figure 2 shows the smart irrigation system. It can be seen the stages related to the smart irrigation system starting from receiving data on environmental temperature, soil, and temperature humidity by sensors at agricultural locations. Then by utilizing an internet connection, the data will be sent to internet cloud services and then stored on internet cloud services. If there are abnormal conditions related to environmental temperature, soil, and humidity, the monitoring section or user will receive a report. Based on the report, the user can give orders through existing applications to the irrigation control system so that irrigation can be done remotely.

2. Pest Control

The reliability of crop disease and pest management systems depends on three aspects: sensing, evaluation, and treatment (supported by IoT technologies) (Zhang *et.al., 2018*). Utilization of IoT in pest management can be done by utilizing tools that have sensors to obtain data or information related to the environment, the state of plants needed to control pests. Examples of tools used to control pests are IoT automated traps, which have the function of automated camera traps and adjustable spray timing. The automated traps can be seen further in the image below (See Fig.3).

Fig. 3. IoT Automated Traps (semios) Source : www.semios.com

Figure 3 shows one of the tools that utilize IoT technology in controlling pests, namely automated traps. In the series of automated traps, there are automatic camera traps, spray timers, and variable rate mating disruption. Automatic camera traps will send pictures as well as the number of catches related to pests daily. Then the spray timer is related to setting the anti-pest spraying device, which can be adjusted as needed. Then the variable-rate mating disruption is to predict the level of pheromone application in response to current pest behavior. Pest control system through automated traps can be seen further in the image below (See Fig. 4).

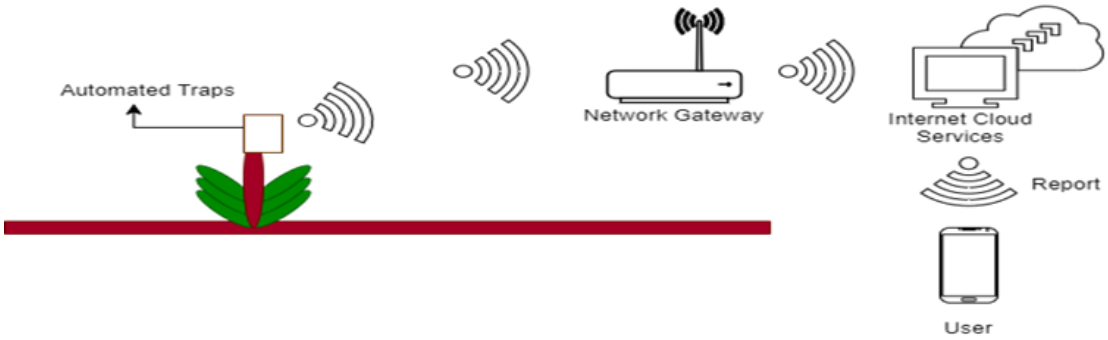

Fig. 4. Pest Control System

Figure 4 shows an overview of a pest control system that uses automated traps. The data generated through IoT automated traps will be transferred to the Internet Cloud System. The entire system that monitors agriculture environmental conditions by utilizing IoT automated traps will automatically provide reports regarding pest problems and automatically provide workers with early warnings regarding pest problems.

3. Smart Poultry Farm

In general, the success of poultry-related production depends on comfortable environmental conditions such as temperature, humidity, and lighting. The IoT concept can be used to determine the condition of poultry through existing sensors to obtain data related to temperature, humidity, and lighting. Then, the data will be directed to internet cloud services and stored. The monitoring department related to the condition of poultry will use available data to determine the real-time condition of poultry, such as stress levels and comfort based on calculations related to temperature, humidity, and lighting. When compared to traditional operations, poultry farming by utilizing IoT has advantages in the form of better reliability and expansion in obtaining information so that it can assist in making decisions in the field in managing poultry, as well as increasing remote control capabilities that will increase the effectiveness and efficiency of operations in the field poultry farming. These advantages will lead to an increase in the quality of poultry-related to health and welfare.

B. Processing

This processing stage is related to the activity of converting or processing raw materials into a product. In the food industry, it is certainly related to food products. IoT can collect data in real-time with this data, optimization of related processes in the food industry can be carried out. With real-time information gathering and intelligent algorithms, the control software can make better decisions to avoid deviations in actuator driving.

With IoT technology, Monitoring capabilities in the processing section can be more easily carried out. Monitoring at the processing stage with real-time data collection by IoT has a positive impact on increasing maintenance. For

example, the use of sensors to monitor the temperature on the machine can be used to take preventive measures when there is information related to temperatures that are out of range (exceeding normal limits) this will certainly prevent engine damage. IoT technology also provides end-to-end transparency capabilities in near real-time. This relates to traceability, which at the processing stage refers to the ability to record or obtain data through RFID tags or other tracking media so that all product processing steps can be monitored better. With traceability, it is possible to optimize the entire line at the processing stage and will increase the efficiency of the processing stage in the food industry. For example, in sauce production, an SME using a machine on the processing stage that utilizes IoT technology to improve traceability shows an increase in income of 30% from previous income (Apriharta *et.al.*, 2021). This example shows that IoT technology can increase the effectiveness and efficiency of the processing stage.

In the processing stage, it is also necessary to pay attention to the packaging of food products. Food packaging is used for protecting food products from external influences such as temperature, lighting, humidity, and others. Technological developments such as the emergence of IoT are changing packaging to be more interactive and safe. Smart packaging with interactive and intelligent packaging concepts is based on the interaction between the packaging environment and food to provide active protection for food products. Smart packaging utilizes sensors to monitor food quality and safety. Monitoring the quality and safety of food products can be done online with smart packaging combined with the IoT concept. The concept of IoT in smart food packaging can be seen further in the image below. (See Fig. 5).

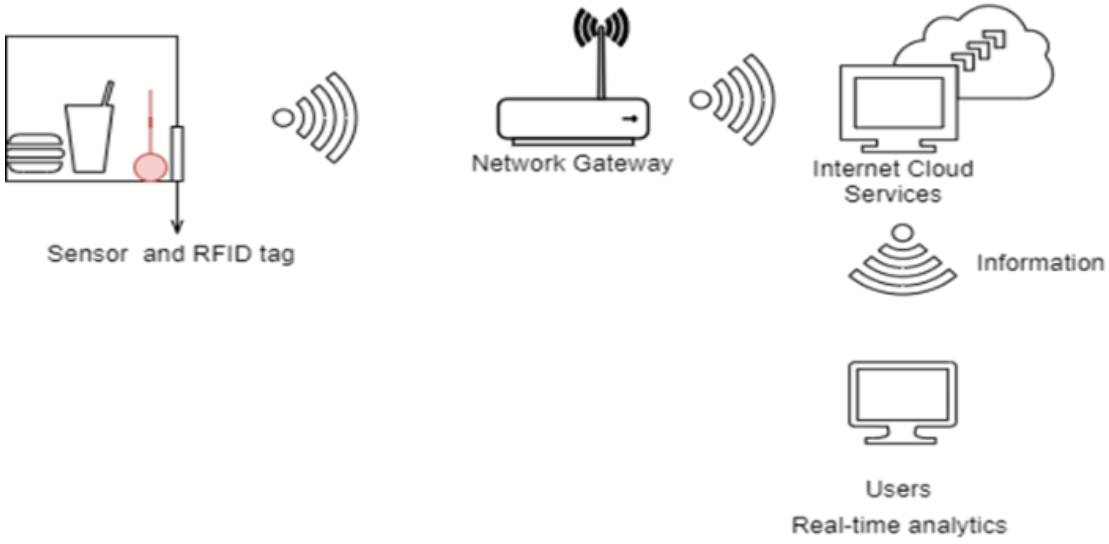

Fig. 5. Smart Food Packaging System

Figure 5 shows a smart food packaging system that utilizes the IoT concept. By embedding sensors on food product packaging such as RFID or smart labels, then utilizes an internet connection, data such as temperature, humidity, and lighting can be directed to the internet cloud service. These data can be used to determine the condition of food, especially related to the quality and safety of food products. Then based on these data, an analysis will be carried out, which will influence the decision-making regarding food product packaging. The utilization of IoT has good potential in developing new sensor systems embedded in food product packaging so it can improve the ability to convey information related to weight and volume control of food products.

C. Distribution

This distribution stage is related to warehousing activities and the distribution of processed products to retailers.

1. Warehouse Management

Warehouse management is an important thing in the food industry because the warehouse is a place to store food products that have been processed. The warehouse can store so many products, so it must be managed properly and optimally to ensure fast and precise performance in all functions so that customer demands can be met while ensuring the condition of the food products in the warehouse. Warehouse management must know all the products to be distributed, using IoT technology to help warehouse management identify existing food products. Warehouse management must also know the conditions related to food products in the warehouse, using IoT technology to help warehouse management receive information when abnormal conditions occur in the warehouse, such as inappropriate temperatures, inappropriate product locations, and low product stocks.

In warehouse management, to ensure good performance in all warehouse functions, generally using sensor technology, RFID, and perceptual technologies such as voice and video monitoring (Juntao, 2016). Improving traceability is one of the keys to improving warehouse management capabilities because, with good traceability, the ability to monitor and identify products in the warehouse will increase. The warehouse management system can be seen further in the image below (See Fig. 6).

Figure 6 shows a warehouse management system by utilizing IoT. The IoT concept on warehouse management system can be utilized to improve traceability is to use RFID tags as a tool to identify, track and obtain data from a target object in the form of food products, then Wireless Sensor Network and actuators to monitor related data obtained by RFID and direct the data obtained to internet cloud services through a network gateway. Internet cloud services will be a place to store data related to food products in the warehouse.

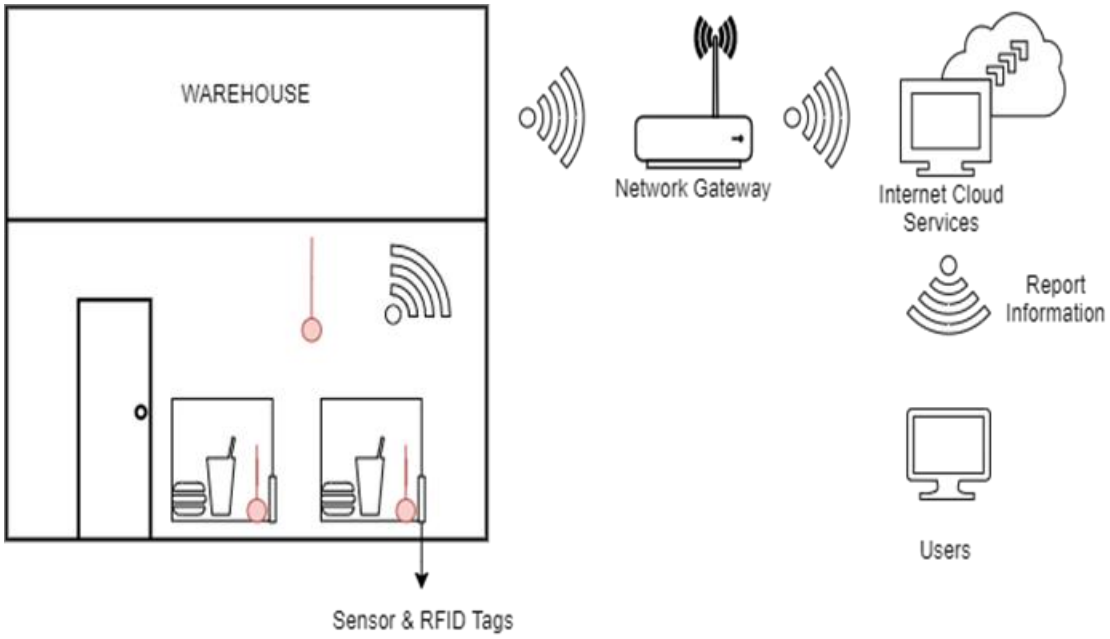

Fig. 6. Warehouse Management System

2. Product Distribution

The distribution of food products needs to pay attention to the quality, freshness of the product, and damage to the product. If the distribution of products does not carry out strict controls, then food products are susceptible to bacteria, accelerate the rate of spoilage, affect product quality and threaten consumer health. During the distribution process, the temperature and humidity of the product must be within a certain range. Otherwise, customer satisfaction with the distributed product will be affected (Chen *et.al., 2020*). The selection of distribution channels is also important because to distribute food products, time is crucial, especially to ensure the quality of food products.

Key technologies related to the use of IoT in the distribution of food products are RFID, sensor technology, video surveillance, and cellular communication technology in the form of the Global Position System (GPS) (Wen & Lv, *2019*).

The IoT concept can be utilized in product distribution by using humidity and temperature sensors on trucks transporting food products. The humidity and temperature sensors will be combined with RFID embedded in the product packaging so that product-related information can be recorded. With an internet connection, the information contained in the RFID will be directed to the monitoring center so that through the monitoring center, the information related to humidity and temperature can be monitored in real-time.

With GPS installed on the product transport truck, information related to the vehicle location, trip status, information related to the lanes can be passed or can be obtained. So that the monitoring center can find out the

condition of the transport truck and ensure on-time delivery.

4. CONCLUSION

This paper studies the food supply chain in the food industry and analyzes the situation according to real conditions. In general, food supply chain management in the food industry is still running manually, thus creating ineffectiveness and inefficiency in the course of the food supply chain, especially in obtaining information. So, in this paper, we introduce the Internet of Things that can be utilized in the food supply chain in the food industry and the internet of things-based information delivery system. This system applies various technologies combined with the concept of the Internet of Things so that the distribution of information in the food supply chain can be carried out more effectively and efficiently.

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