



Food safety pre-warning system based on data mining for a sustainable food supply chain



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ABSTRACT

In recent years, the food safety incidents happened frequently in china, and then the problems related to food quality and safety have attracted more and more social attention. Considering the concern with regard to quality sustainability in food supply chain, many companies have developed a real time data monitoring system to ensure products quality in the supply chain network. In this paper, we proposed a food safety pre-warning system, adopting association rule mining and Internet of Things technology, to timely monitor all the detection data of the whole supply chain and automatically pre-warn. The aim of pre-warning system is to help managers in food manufacturing firm to find food safety risk in advance, and to give some decision support information to maintain the quality and safety of food products. A case study of a dairy producer was conducted, and the results showed that the proposed pre-warning system can effectively identify safety risks and accurately determine whether a warning should be issued, depending on the expert analysis when an abnormality is detected by the system. In addition, implications of the proposed approach were discussed, and suggestions for future work were outlined.

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1. Introduction

The food supply chain has faced increased quality risk, caused by the extended global supply chain and increased consumer demands on quality and safety (Tse & Tan, 2011). Since all the food safety information comes from every partner in the supply chain, unpredictable risks also exit in the data transmission (Appleauist, Pekny, & Reklaitis, 2000). With the development of Internet of Things (IOT), which provides better support to achieve effective supply chain information collecting and sharing, a data mining technology has been recently developed for the identification of vulnerabilities and the pre-warning of food safety along the farm-to-fork chain (Verdouw, Wolfert, Beulens, & Riialand, 2016). This leads to the design of a system that can analyze food safety risk and pre-warn based on some food safety and quality assurance rules. Thus, each operation in different supply chain steps has the potential to be developed to reduce quality uncertainty and resource waste, and eventually avoids food safety incidents (Ting, Tse, Ho, Chung, & Pang, 2014). What is more, the food safety pre-warning

is an effective way to achieve sustainability in food supply chain, since the quality sustainability is the most important for a sustainable food supply chain (Reisch, Eberie, & Lorek, 2013).

Food safety pre-warning represents a continual challenge for supply chain managers in food industry. Most companies now are a part of the food supply chain which usually crosses a number of interested parties to reach the end user, and the severity and complexity of the product quality problem have been aggravated, since more members join the supply chain (Kuo & Chen, 2010). In such a complicated and competitive environment, firm executives may fail to anticipate the cascading effect that occurs routinely throughout their supply chain operations (Lamarre & Pergier, 2009). In the most serious case, the unsafe product may trigger a product recall that becomes a nightmare for the supply chain members. Another uncertainty factor that influences the effectiveness of product quality assurance is poor visibility in the supply chain (Roth, Tsay, Pullman, & Gray, 2008). The dramatic increase in product recalls reveals that those multi-tiered supply chains with low transparency are particularly vulnerable to food safety risk (Tse & Tan, 2012). However, the consumers require better production processes and high quality products, which promotes the food supply chain enhance quality-sensitive. Competition among supply chains have gradually turned to quality-based competition (Foster, 2008). Moreover, because the demand for the freshness of food and

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the degree of process transparency is increasingly growing, much attention is being paid to the monitoring of temperature, microbiological information and other food quality parameters (Abad et al., 2009; Heising, Dekker, Bartels, & Van Boekel, 2013). Hence, there is a need for research in extended supply chain sustainability improvement, and the role of information sharing and food safety pre-warning are essential to achieve these goals.

Information sharing can strengthen the communication and coordinate the cooperation between nodes of supply chain to enhance the sustainability of food supply chain (Ahumada & Villalobos, 2009). Internet of Things (IOT) is applied to achieve the information sharing, which has broad prospects in the food industry. It enable supply chain actors to achieve real-time process monitoring, collect and transmit information, and solve the problem of food supply chain transparency (Atzori, Iera, & Morabito, 2010). In addition, IOT technology allows supply chains to use virtualizations dynamically in operational management processes, which improves support for food companies in dealing with perishable products, unpredictable supply variations and stringent food safety and sustainability requirements.

Given that the concern with regard to food safety problems in the food supply chain, a lot of methods is being implemented to solve the problems, and the pre-warning is one of them, which can find and report problems before the crisis. The pre-warning process is often applied in some traceability systems based on the Hazard Analysis Critical Control Point (HACCP) Standard (McAnelly, 1994), such as the animal production information traceability system in china. Currently, since the fact that there are many actors and passages involved in food supply chain, the marketing logistic become more complicated than before, which makes it more difficult to regulate, monitor and control the food product trade (Watsona & Pauly, 2013). Therefore, most food safety incidents are caused by the ineffective supervision, and there is a need to apply a pre-warning system to supervise the product trade automatically and efficiently.

Based on the reasons above, we decided to focus on the effective pre-warning system to ensure the products safety in a sustainable food supply chain. In this study, we proposed an information

sharing model to collect data based on IOT, and a food safety pre-warning system was employed to reveal possible food safety risk with regard to some safety assurance settings which were found by data mining in the retrospective database. The RFID technology was adopted in the proposed information sharing model to monitor and capture food safety data (Mo, Lorchrachoonkul, & Gajzer, 2009), and association rule mining techniques were employed to data mining for the good logistics plans, which were used to transport food products in the distribution network, so as to find the food safety pre-warning rules. In the proposed pre-warning system, firstly, the data processing and cleaning was completed in the first stage; secondly, the association rule mining model was built to find the warning rules; finally, the food safety pre-warning in the supply chain was achieved by using the warning rules. In order to test the validity of the proposed method, a case study was conducted with a dairy supply chain, and its test results were evaluated by a focus group of academics and industrialists.

2. Materials and methods

2.1. Information flow under information sharing model based on IOT

To achieve the food safety pre-waning in food supply chain, faster response speed is very important (Qi, 2006). Based on Internet of things (IOT), we proposed an information sharing model, which can take advantages of information sharing to coordinate the operation among nodes of the supply chain, to ensure the food safety pre-warning system operate efficiently and safely.

The information center is the hub for information exchanging, which can collect and store information from all relevant steps in the food supply chain. The center's database records all the food safety related data, mainly including product and logistic information. What is more, the information center can continuously monitor and analyze the food safety data to find the abnormal situation. Therefore, it can give warning to each stakeholders at all steps in time when the food safety risk occurs. Fig. 1 shows

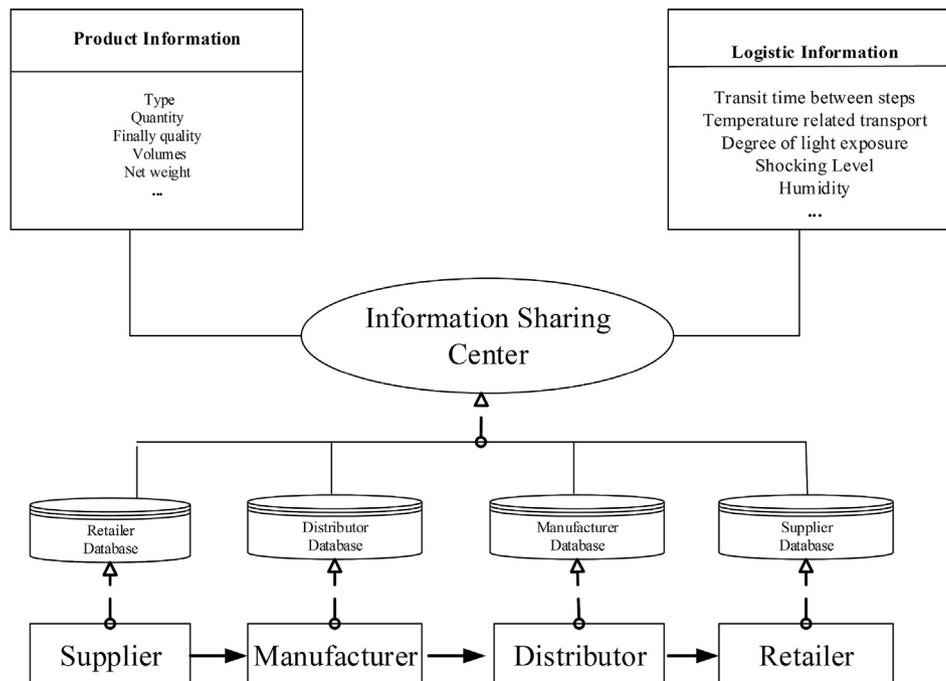


Fig. 1. Information flow under information sharing model based on IOT.

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