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An improved traceability system for food quality assurance and evaluation based on fuzzy classification and neural network

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ABSTRACT

Currently, the food safety incidents happened frequently in china and the customer confidence declined rapidly, then the problems related to food quality and safety have attracted more and more social attention. Considering the concern with regard to food quality assurance and consumer confidence improvement, many companies have developed a traceability system to visualize the supply chain and avoid food safety incidents. In this paper, we proposed an improved food traceability system which can not only achieve forward tracking and diverse tracing like the existing systems do, but also evaluate the food quality timely along the supply chain and provide consumers with these evaluating information, to mainly enhance the consumer experience and help firms gain the trust of consumers. For the food quality evaluation, the method of fuzzy classification was used to evaluate the food quality at each stages of supply chain while the artificial neural network was adopted to derive the final determination of the grade of food quality according to all the stage quality evaluations. A case study of a pork producer was conducted, and the results showed that the improved traceability system performed well in food quality assurance and evaluation. In addition, implications of the proposed approach were discussed, and suggestions for future work were outlined.

1. Introduction

The food supply chain has faced increased quality risk, caused by the extended distance that food travels from producer to consumer as a result of globalization in food trade (Tse & Tan, 2011). Therefore, keeping safety and quality along the food supply chain has become a significant challenge. During the last couple of decades, the credibility of food industry was heavily challenged after a number of food crises and incidents, such as Bovine Spongiform Encephalopathy (BSE) or mad cow diseases, Food-and-Mouth Disease (FMD)and China's tainted milk scandal (Myo & Yoon, 2014). Therefore, customers call for high quality food with integrity, safety guarantees and transparency (Beulens, Broens, Folstar, & Hofstede, 2005; Trienekens & Zuurbier, 2008). With the development of information technology, the food traceability system has become popular recognized method for food quality assurance and broadly disseminated in the food industries, since it can reduce individuals' concerns about food safety by providing unambiguous information about the safety and quality of the whole process from producers to consumers (Badia-Melis, Mishra, & Ruiz- García, 2015; Cozzolino, 2014; Lin, Mark, Zetian, Trebar, & Xiaoshuan, 2014; Melo, Andrew, & Faleiro, 2015).

Food traceability is defined as a part of logistics management that capture, store and transmit adequate information about food, feed, food-producing animal or substance at all stages in the food supply chain so that the product can be checked for safety and quality control, traced upward, and tracked downward at any time (Bosona & Gebresenbet, 2013). In general, the food traceability system is aim to effectively manage accidental safety risk, gain maximum consumers' trust, facilitate value-based and value-added marketing, promote quality improvement within an organization and a supply chain, support animal well-being and achieve precise agriculture (Lavelli, 2013). The benefits associated with these objectives include lower cost distribution systems, reduced recall expenses and expanded sales of products with attributes that are difficult to discern (Golan et al., 2004). Thereby, most companies have implemented the traceability system in their daily business.

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However, the existing food traceability system 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 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 most serious case, the unsafe product may trigger a food safety incident 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 food safety incidents reveals that those multi-tiered supply chains with low transparency are particular vulnerable to food safety risk (Tse & Tan, 2012). And more and more managers have now figured out that the huge data stored in the system are very valuable in today's highly competitive market and the food traceability system can probably carry out more other functions by making full use of these valuable data to enhance enterprise competitiveness and gain the trust of consumers. Meanwhile, customer demand for the food quality and the degree of process transparency is increasingly growing and they want more scientific and professional food quality evaluating information to help them make intelligent purchasing decisions and buy the high-quality products to meet their own needs (Jin & Zhou, 2014).

Considering the reasons above, we decided to focus on an effective traceability system with the quality evaluating function to mainly help companies to ensure the food quality and improve the customer satisfaction as well. In this study, we proposed an improved food traceability system for quality assurance and evaluation based on the fuzzy classification and artificial neural network (ANN). Different from the existing traditional food traceability system, it could not only achieve forward tracking and diverse tracing for products in the supply chain, but also evaluate food quality based on the related traceability information recorded in the system, which can provide more information such as the quality level of the product for consumers and related stakeholders to enhance the consumer experience. The method of fuzzy classification was used to evaluate the food quality at each stages of supply chain while the artificial neural network was adopted to derive the final determination of the grade of food quality according to all the stage quality evaluations. Hence, the firm could manage the food quality step by step and find food safety risks immediately to avoid the cascading effect and ensure the food quality along the supply chain. In addition, the customer could get the final grade of food quality and quality evaluation at each stage of supply chain by using the improved traceability system to help them make intelligent purchasing decisions and improve their confidence as well. In order to test the validity of the proposed method, a case study was conducted with a pork supply chain, and its test results were evaluated by a focus group of academics and industrialists.

2. Materials and methods

2.1. The framework of the food traceability system

In order to minimize the production and distribution of unsafe or poor quality products as well as improve consumer confidence, we proposed an improved food traceability system for quality assurance and evaluation based on fuzzy classification and artificial neural network. It possesses three main subsystems that traceability information collecting, information processing and information query. Fig. 1 shows the improved food traceability system.

The traceability information collecting subsystem is the foundation of the traceability system. In this subsystem, all supply chain actors are considered to have internal and external traceability in order to achieve the whole supply chain traceability (Alfaro & Rábade, 2009). The safety and quality regulations, such as GMP, GHP and HACCP, enforce all actors to manage all their operations in an efficient and standard manner, which is very important for the food quality assurance (Blanchfied, 2005). For supply chain operation and performance, enabling technologies can be regarded as facilitators which serve as a medium for all actors to enable access to food traceability information collecting subsystem.

The information processing subsystem is the most important and innovative part of the traceability system. It consists of three main functional modules, namely the forward tracking, diverse tracing and quality evaluation. Based on an enormous variety of different traceability information created in the whole food supply chain, such as raw material information, production information, distribution information, sales information and consumer information, the product can be traced upward and tracked downward at any time so that the problem of food supply chain transparency can be solved, which is the most concern to consumers currently (Pizzuti, Giovanni, Miguel, & Fernando, 2014). In the quality evaluation module, firstly the key data related to food quality at every stage of the supply chain will be extracted, then the classification of food quality at every stage of the supply chain will be calculated respectively by using the method of fuzzy clustering, finally combining the analysis of quality control in every steps of the product, the final evaluation of food quality will be given by using an artificial neural network.

The information query subsystem is the output end of the traceability system. Based on the information and web technologies, the related stakeholders, such as consumers, regulators and companies, can query and retrospect the product quickly and easily by many ways, such as SMS, telephone, Internet and mobile clients.

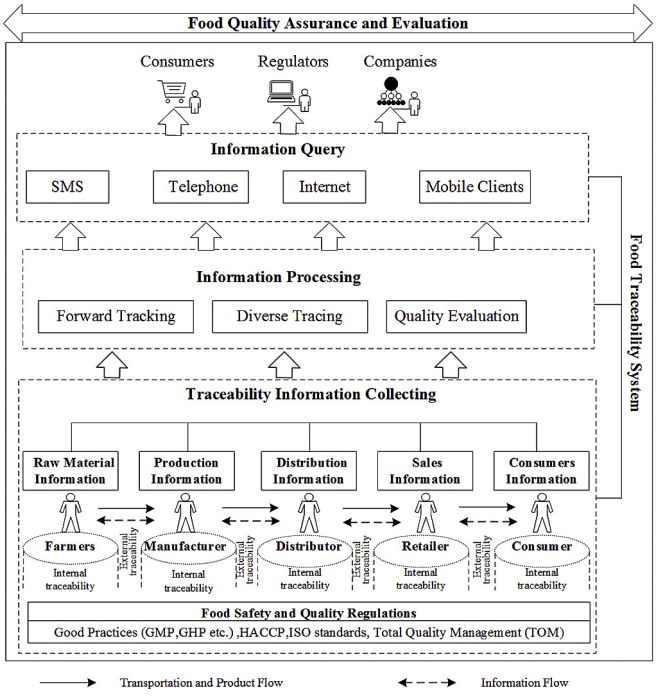

Fig. 1. Architecture of the improved food traceability system.