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Food traceability: New trends and recent advances. A review

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ABSTRACT

Current traceability systems are characterized by the inability to link food chains records, inaccuracy and errors in records and delays in obtaining essential data, which are fundamental in case of food outbreak disease; these systems should address the recall and withdraw of non-consumable products. The present paper provides a review of the various latest technological advancements such as innovative implementations of RFID that can make to increase the sales of wheat flour, or allowing the consumer to know the full record of the IV range products through the smartphone; knowing the food authenticity with an isotope analysis or by analysing the DNA sequences. There are also presented some conceptual advancements in the field of food traceability such as the development of a common framework towards unifying the present technical regulations, the interconnectivity between agents, environment loggers and products, all of them in the form of Internet of things system as well as the development of intelligent traceability, where it is possible to retrieve the temperature of a product or its remaining shelf-life.

These new techniques and concepts provide new opportunities for enhancing the efficiency and compatibility of the present traceability systems.

1. Introduction

After a detailed investigation of the true definition of traceability Olsen and Borit (2013), came with a compendium of all the definitions saying that traceability is “The ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications”.

Food traceability pretends to be of high potential for consumer's protection by targeting precisely the recall, eliminate the non-consumable food products and promoting the investigation of the causes of food safety issues; all of that by being an integral part of food safety, food quality, food defence and intrinsic requirement of the food supply-chain. The worldwide acceptance of the food traceability such as Patagonia traces in Argentina (Welt and Blanchfield, 2012), merging of GS1 Australia with Efficient Consumer Response Australasia (ECRA), supported by the Australian Food and Grocery Council (AFGC) and other key government agencies and department to establish a portal for all products recall and withdraw (Australia GS1, 2010), National Agriculture and Food Traceability System (NAFTS, 2013) in Canada, the embracement of “Internet of Things” and establishment of a future cloud computing centre in Shanghai's Jinshan district to ensure food traceability in China (Anon, 2011), European Union (2002) regulation no. 178/2002 and EU Rapid Alert System for Food and Feed (RASFF), use of tracking and tracing software Grapenet for export of table grapes from India to EU (Bujji, 2012), introduction of full beef traceability system in Korea (ICT in 2011), the US Bioterrorism Act (2001, H.R. 3448) and the Food Modernization and Safety Act (FMSA, 2011. H.R. 2751) in USA, further strengthen the faith of global community in Food Traceability. Therefore since traceability is a well-known concern for the majority of the food industry, a study like the presented here aims to bring some perspective about the new trends and recent advances, presenting the newer technological and conceptual techniques and showing their novelty.

Pizzuti, Mirabelli, Sanz-bobi, and Goméz-gonzaléz (2014) write about the inability to link food chains records that characterizes the current traceability systems, also describes the inaccuracy and errors in records and delays in obtaining essential data. The access to this information is key in case of a food outbreak disease and it's necessary for the job of food safety agents.

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Also traceability has driven many issues related to Food crisis management, traceability of bulk products, Quality and identity-preservation concerns and Fraud prevention and anti-counterfeiting concerns in the past years (Dabbene, Gay, & Tortia, 2014). USDA Economic Research Service states that besides ensuring a safe food supply, use of traceability system results in lower cost distribution systems, reduced recall expenses, and expanded sales of products with attributes that are difficult to discern (Golan, Krissoff, & Kuchler, 2004). Even many food producers have good electronic traceability system internally, but exchange of information between the links in the supply chain is very time consuming or difficult due to the diversity and proprietary nature of the respective internal systems (Storøy, Thakur, & Olsen, 2013) hence, they do not realize the true value of using an electronic traceability system as the cost of installing technology and operating the system exceeds the benefits.

So there is a need of a change, where all the agents in the supply chain stand to gain, there are new trends in the Food Traceability sector focused on improving the processes such as Food Track and Trace Ontology (FTTO) and Critical Tracking Point (CTE) combined within the TraceFood Framework, can provide new advances for improving the efficiency and compatibility of the present traceability system. On one hand the Critical Tracking Event provides fast and effective food traceability system (McEntire et al., 2010) with security in terms of data ownership, data access and proprietary information protection, and Food Track and Trace Ontology provides integration among heterogeneous databases enabling interoperability among different systems (Pizzuti et al., 2014), which is not a common fact in Food Traceability, in the other hand TraceFood Framework provide principles and guidelines for implementing traceability in food value chains. The growing diffusion of new technologies coupled together with the availability of new computational and simulation models seems to be significantly improving the present value of Food Traceability and would solve the problems of no communication between agents and provide a solid and homogeneous line to work, instead having a whole variety of rules completely heterogeneous.

Tracking and tracing can only be effective; if it is implemented as a sector encompassing systems approach (Fritz & Schiefer, 2009). In order to do an efficient product monitoring, the industries have always required an easily applicable and low cost traceability technique, the most recent advances can offer efficiency with the latest technologies such as chemometrics modelling, isotope analysis or DNA barcoding despite of not being the cheapest techniques. And in the other hand wireless monitoring devices are still being improved and implemented in many innovative research studies (Badia-Melis et al., 2014; Badia-Melis, Brecht, Lowe, & Uysal, 2013; Badia-Melis, Ruiz-Garcia, Garcia-Hierro, & Robla, 2015; Lin, Mark, Zetian, Trebar, & Xiaoshuan, 2014; Zou, Chen, Uysal, & Zheng, 2014), with the purpose of bringing an affordable and easy way of traceability.

Supply chain visibility is being pushed to a new stage by government regulations and consumer requirements; it means that food traceability is becoming a reality, reality that will go from "farm to fork" (Min Aung & Seok Chang, 2014).

2. Technological advancements

In the recent years as the world has become more global, food traceability has gained importance, traditional methods are not enough for certain products and the necessity for obtaining food records has increased, the recent advances in terms of technology are summarized in Table 1.

2.1. RFID, still a promising tool for traceability control

The current advancements in RFID technology and the incorporation of integral parts such as data logger capabilities and integrated sensors, has provided a new dimension to the application of RFID technology in the food traceability systems, as it is gathered in the article of Ruiz-Garcia and Lunadei (2011), the applications of RFID to the food traceability are many and varied. During the last decade RFID has emerged as a lead actor in the development of traceability systems in the food supply chain and their implementations are increasing at a fast rate (Costa et al., 2013). With the implementation of RFID technology, food traceability systems can become more reliable and efficient since RFID enables a higher reading rate than traditional barcodes (Hong et al., 2011). With identification of the products without any physical contact, the RFID technology provides effective information sharing with efficient customization and handling (Zhang & Li, 2012). Kelepouris, Pramatari, and Georgios Doukidis (2007) proposed an infrastructure using RFID, where it was compared with the traditional lot numbering and internal information systems, it has the advantages of automatic identification, uniform EPC for all partners, small investment in equipment and easily drawn information.

Agro-food logistics and supply chain management processes for food traceability using RFID are discussed since some years ago by several authors, i.e. Jones, Clarke-Hill, Shears, Comfort, and Hillier (2004), Angeles (2005), Twist (2005), Attaran (2007), Ngai, Cheng, Au, and Lai (2007), Sugahara (2009). Also quality oriented tracking and tracing systems FEFO implementing Radio Frequency Identification tags, is a topic argued in the literature (Emond & Nicometo, 2006; Koutsoumanis, Taoukis, & Nychas, 2005; Scheer, 2006). Amador and Emond (2010) developed a system of RFID temperature tracking for combat feeding logistics. The capability of hosting sensors of the tags allows the called "cold traceability", concept that has been introduced to trace groups of temperature-sensitive products are transported in different atmosphere requirements (Ruiz-Garcia, Steinberger, & Rothmund, 2010).

A Wheat Flour Milling Traceability System was developed by Qian et al. (2012) (WFMTS), incorporating 2D barcode and RFID technology, to validate the system in wheat flour mill in China. Labels with a QR Code were used to identify small wheat flour packages, and RFID tags were used to identify wheat flour bins and record logistics information automatically. They obtained that the total cost of the system increased by 17.2% however, with the new system the sales income increased by 32.5% and proved the high potential of good application of WFMTS in medium and large wheat mill enterprises.

Feng, Fu, Wang, Xu, and Zhang (2013) developed and evaluated a cattle/beef traceability system, which integrated RFID technology with PDA and barcode printer. They obtained real-time and accurate data acquisition and transmission, and the high efficiency of information tracking and tracing across the cattle/beef supply chain.

Barge, Gay, Merlino, and Tortia (2014) automatically recorded cheese wheels movements during the production, handling in the maturing room and warehouse, delivery, packing and selling phases in a dairy factory with the help different techniques by fixing RFID tags to the cheese. They considered factors such as tag type and shape, required power, antennas polarization and orientation, fixing method and ripening duration to verify their effect on reading performance and system reliability.

Catarinucci et al. (2011) used a combination between WSN and RFID, in order to enhance the traceability of the white wine from vineyard to consumer glass. WSN is a wireless technology like RFID also tried in many other authors to improve the traceability in food