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REVIEW ARTICLE DERLEME MAKALESİ

DETERMINATION TOOLS OF ORIGIN IN THE FOOD TRACEABILITY

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Abstract:

Traceability concept that is often discussed together with foodborne problem has been developed rapidly with technology and it is key position of safety and quality of food. As a result of globalization, food production and consumption locations become distant. Therefore, the importance of traceability work is increasing. Origin of the food that the starting point of the food traceability is the first step of traceability. Determination of food origin are important in traceability as a key of food quality and safety. Food safety and traceability is impossible in food that could not be determined origin. The main aim of this study is investigate the method to determine the origin of the food. Origin detection means is considered as an important part of the food traceability. The methods used in order to determine the origin of the food is divided into as geographic-based and analytical methods. Geographic-based origin determination methods are evaluated in two subgroups as mineral isotope and GIS (Geographical Information System). Analytical and bio-based tools, DNA, enzymes, mass spectrometry, spectroscopy, and based on electrokinetic and separation were examined by making detailed literature search.

Keywords: Food traceability, Food origins, Determining the origin

Introduction

Food safety problems increases the concerns of consumers in the world which causes press from consumers and legal authority to food premises. As a result of this case, the transparency of the whole process of food production and supply chain ensured. In this context, the importance of traceability systems is increasing day by day. Food production and consumptions are done in different places due to the development in the global economy. This case requires more controlled monitoring in each stage of the product.

Determination of the origin of the food seems to be identity cards of food and it is also indispensable starting point for food traceability. Determination of the origin of raw material provides information like where it came from and its physical and chemical properties.

Traceability in the Food Industry

Traceability has great importance in food industry. Producers want to monitor products and follow the product not only forward but also backward. Manufacturers also want to find trouble spots quickly and intervene in the food chain. In this context, food traceability is seen as a food safety and crisis management tool.

The consumer is located at the final stage of food safety chain and wants to information about each stage of the product consumed. At the same time, food traceability is regarded as a precondition of food quality, food security and public health and is legal obligation in many countries around the world.

Food Traceability Concept

Traceability is defined as monitoring current stages of food production, processing and transportation by Codex (Codex Alimentarius, 2004). Traceability is defined as a problem preventive, and when it is used properly, it increases the efficiency of the food business promoting food safety system in a different definition that is related food safety and traceability (Aarnisalo et al., 2007).

The main purpose of traceability is to reach the stories of food in the entire supply chain from farm to fork product (Opara, 2003), to obtain the location of the information and stories of different products (Dabbene and Gay, 2011). The sub-objectives can be developed with the following main purpose;

- To improve food safety
- To identify potential sources of contamination,
- To facilitate recall procedure of product,
- To control public health risks resulting from the consumption of the product (Raspor, 2005).

There are many research studies on different foods or food components. Halal meat traceability (Zailani et al., 2010), traceability of fruit and vegetables (Kondo, 2010; Bontempo et al., 2011), grain supply chain (Thakur et al., 2009) and oil production of traceability (Liu et al., 2009), traceability of Genetically Modified Organisms (GMO) (Miraglia et al., 2004) and seafood (Schroder, 2008) are some of them.

Advantages of Food Traceability

Different stakeholders are provided with benefits by food traceability systems in different sizes. These stakeholders are managers, customers, suppliers or producers. Stakeholders also benefit from management, quality control and economic by traceability system.

The main benefit of traceability is to ensure information about food products in the food chain. Providing early warning systems for avoiding quality problems and recalling effectively are some of the benefits (Van-dervorst, 2006). The main benefits of traceability are termed direct benefits by Regattieri et al., (2007) and direct benefits are supply chain optimization, product quality and market advantage (competitive advantage in marketing).

In another study, the expected benefits from traceability systems are summarized as follows:

- Effective and accurate risk management in the product and production process
- Optimal usage of raw materials,
- Reducing the high inventory levels and optimizing production planning,
- Extending the product life cycle and minimization of costs,
- Refreshing the traceability data automatically,
- Providing an effective recall management Wang and Li (2006).

In addition to the benefits of traceability systems, it is possible to utilize the following benefits:

- Providing information to consumers about food safety and origin,
- Identification of infection source,
- Controlling disease and monitoring residual,
- Identification of substandard products (Leat et al., 1998) and determining the cause and effect relationships,
- Facilitating the data of recall in quality management (Moe, 1998),
- Increasing transparency of enterprise,
- Providing more efficient logistics management,
- The effective control of livestock-borne diseases, control of infectious animal diseases and ensuring the elimination (Meuwissen et al., 2003),
- Increasing the value and profits of food products (Golan et al., 2004),
- Protecting food safety and public health due to reducing of food-borne diseases,
- Faster detection of new hazards (Souza-Monteiro and Caswell, 2004).

Food traceability providing advantages in management is a legal requirement in the majority of developed countries in the world (Dabbene and Gay, 2011).

Traceability System

Traceability systems ensuring food safety and quality are located on a key point for enterprises and regulators in recent years. Traceability systems are variable according to the size and type of plant, product range and specifications and technological opportunities of enterprise. In the direction of these variables, traceability systems are changed from simple paper-based applications to specific computer-based systems.

In addition to practice examples, scientific literature has got different ideas, approaches of interdisciplinary and new applications about traceability. In the literature, there are a number of studies on computer-based food chain monitoring systems and modelling (Bello et al., 2004), new methods developed in food packaging (smart packaging, nanocomposite applications, etc.) (Mahalik and Nambiar, 2010), wireless sensors used food traceability (Ruiz-Garcia et al., 2009), molecular markers (Martins-lopes et al., 2013), RFID (Radio Frequency Identification) based monitoring systems (Bernardi et al., 2007), FMECA (Failure Mode, Effects and criticality Analysis) and method used with HACCP (Hazard Analysis Critical Control Point) (Bertolini et al., 2006). Spectroscopic methods intended to determine the geographical origin (Herrero et al., 2012; Castro-Puyana and Herrero, 2013) and studies on the basis of isotope and mineral substances (Bontempo et al., 2011) are arisen as the newest approaches.

Origin Detection Tools in Food Traceability

Origin of food is one of the most important criteria for ensuring food quality. At the same time, origin is indispensable basic point in quality concept from farm to fork. In this context, origin detection tools are regarded as important parts of the food traceability. Geographic, biological and analytical-based methods are the main methods in determining the origin of the food.

Geo-Based Applications Tools

Geo-based monitoring tools have been developed as new methods in recent years. They are generally used for traceability of food-agriculture and agricultural products. Mineral isotope and GIS (Geographical Information System) are the main tool of the geographic-based applications.

The structures transferred from soil to food are the basis of multi isotope method, because these structures can serve as an indicator. According to Kelly et al. (2005), unique signs and information of food origin are offered by composition and structure of soil. Chemical and isotopic composition (separately or together) determine the basic characteristics of the food which has been used for last thirty years (Bontempo et al., 2011). Particularly alkali metals such as Rb and Cs are good geographical identification indicators by moving in the ground easily (Kelly et al., 2005). Furthermore, endangered species are preserved with knowledge of the geographical origin (Schroder, 2008).

GIS is used as a spatial information management tool and GIS is an information system offering combination of computer graphics and geographical locations. Absolute knowledge are provided by GIS to manage, organize and analyse data. GIS can also be integrated with GPS and GSM (Qu et al., 2007).

The main purpose of the geographical information system is combining traceability data of the product with geographic information (Cebeci and Boğa, 2009). The most important factor separating the GIS system from other information systems is all data based on the location (Ramirez, 2004).

The benefits of geographical traceability are as follows;

- Accessing information about the place and manufacture method of the product,
- Increasing consumer confidence in terms of health, environmental protection, sustainable production, choices of socio-economic, cultural and ethical,
- Provide added value to the authentic product,
- Ensuring a competitive advantage to enterprises,
- Informing consumers about production methods and product history,
- Increasing consumer confidence in the brand and the product (Cebeci and Boğa, 2009).

According to Ramirez (2004), GIS can be used as a tool to assist biological risk management and planning in the future.

Analytical and Biological Based Tools

Biological and analytical based tools are analysed as DNA, enzymes, mass spectrometry, spectroscopy, and electro kinetic separation. Analytical and biological based methods are often used for various purposes such as food contaminants, GMO's detection and determining the geographical origin of food. For these purposes, instrumental analysis methods that have different operating principles are used.

These methods are listed as PCR (Polymerase Chain Reaction), ELISA (Enzyme Linked Immunosorbent Assay), MS (Mass Spectrometry), IRMS (Isotope Ratio Mass Spectrometry), ICP-MS (Inductively Coupled Plasma Mass Spectrometry), GS-MS (Gas Chromatography Mass Spectrometry), NMR (Nuclear Magnetic Resonance Spectroscopy) IR (Infrared Spectroscopy), ASR (Atomic Spectroscopy), VS (Fluorescence Spectroscopy), HPLC (High Performance Liquid Chromatography), GC (Gas Chromatography) and CE (Capillary Electrophoresis).

DNA-based methods

Nowadays, the most commonly used method is PCR in DNA-based methods (Miraglia et al., 2004). PCR is used in various processes such as identification of food contents, GMO identification, and agricultural origin identification (Aarnisalo et al., 2007). It has an important position especially in food origin determination (Luykx and Ruth, 2008). PCR technique following the product determines the amount of nucleic acid. Besides, PCR is considered as a powerful and sensitive technique (Martins-Lopes et al., 2013).

In addition, microchips, micro-satellite, DNA-markers and DNA fingerprints are located as different DNA-based methods. DNA, molecular material, is very suitable for traceability because DNA is unique identifier and cannot be changed (Pascal and Mahe, 2001).

DNA microchips make possible to research in many different sequence at the same time. Micro-satellites that one of new DNA applications are used to determine the origin of the animals in along the food chain. DNA - markers which another technique is used for the detection of foreign substances in food (Aarnisalo et al., 2007). Largest constraint in the implementation of this method is cost due to the use of high-tech equipment (Germain, 2005).

Enzyme-based methods

Enzyme-based traceability tools are used in various implementations such as verifying suitability of meat and dairy products (Aarnisalo et al., 2007) and determining of the authenticity in fish, fish products and fruit juice and detection of GMO or allergen (Asensio et al., 2008). ELISA is the most commonly used enzyme-based method with high sensitivity and it is economic that is considered as a laboratory analysis method working with high efficiency (Ahmed, 2002).

Mass spectrometry-based methods

Generally, mass spectrometry-based methods are MS, MS, ICP-MS, GC-MS. These methods serve as traceability tools in combination with different methods. Residues of antimicrobial, antibiotic, and pesticide in food are detected by MS-based methods (Herrero et al., 2012).

Chemically different content is distinguished by IRMS. Geographical origin of the food is determined by ICP-MS analysing inorganic elements. On the other hand, qualitative and quantitative analysis and geographical origin determination can be administered by GC-MS method (Luykx and Ruth, 2008).

Spectroscopy based methods

Generally, spectroscopy-based traceability tools are NMR, IR, AS. NMR method is used for the analysis of semi-solid and liquid food. Finding fingerprint of the sample is considered to be an easy method (Aarnisalo et al., 2007). IR is a method

based on infrared light (absorbed by sample) intensity and wavelength measurement. FS is a method which can analyse both solid and liquid samples. Also, FS can inform about the structure, stabilization and formula of the sample. The structure of metallic and non-metallic in sample is analysed by AS (Luykx and Ruth, 2008).

Separation based methods

Generally, separation based methods are HPLC, GC and CE. Chromatography is based on absorption and separation between still and motion phase of molecules (Aarnisalo et al., 2007).

HPLC is a chromatographic method used for determining the amount of soluble and insoluble content in the solution. Different content such as carbohydrate, fat, protein, vitamins, mycotoxins, vitamins and proteins are analyzed by HPLC (Luykx and Ruth, 2008). HPLC is not only an accurate and quick analysis but also considered as an ideal method for determining phenolic compounds and organic acids (Aarnisalo et al., 2007).

The GC is one of the universal separation techniques used in food analysis. In general, volatile and semi-volatile structures, flavorings and pesticides are analysed by GC (Luykx and Ruth, 2008). Problems that may occur with GC are possibility of contamination of the sample or column. However, rapid, reproducible and operation of a small amount of sample is observed as a GC advantage (Aarnisalo et al., 2007).

CE, is an electro kinetic separation technique. Components are separated by this method based on the difference electro kinetic mobility. CE can be used in various analysis from simple inorganic ions, small organic molecules, peptides to viruses and microorganism (Luykx and Ruth, 2008).

Conclusion

Consumer awareness is increasing day by day. Now, healthy and safe products that provide traceability are demanded by consumers and this request are ensured by developing technology.

Concept of food traceability must be evaluated with total quality from farm to fork. In this context, food origin that is a first step in quality is the base point for ensuring the quality of the whole process.

Determination of original methods, in general, can give us information about the origin and content of food and they play an important role in the traceability studies. Rapid development of information technology also affects the work of determining the origin. Besides, the number of simple, fast and comprehensive techniques is increasing. Consequently, the development of food traceability is beneficial both in raising awareness of consumers and formation of food safety.

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