Research on the risk factors affecting food traceability in the food supply chain

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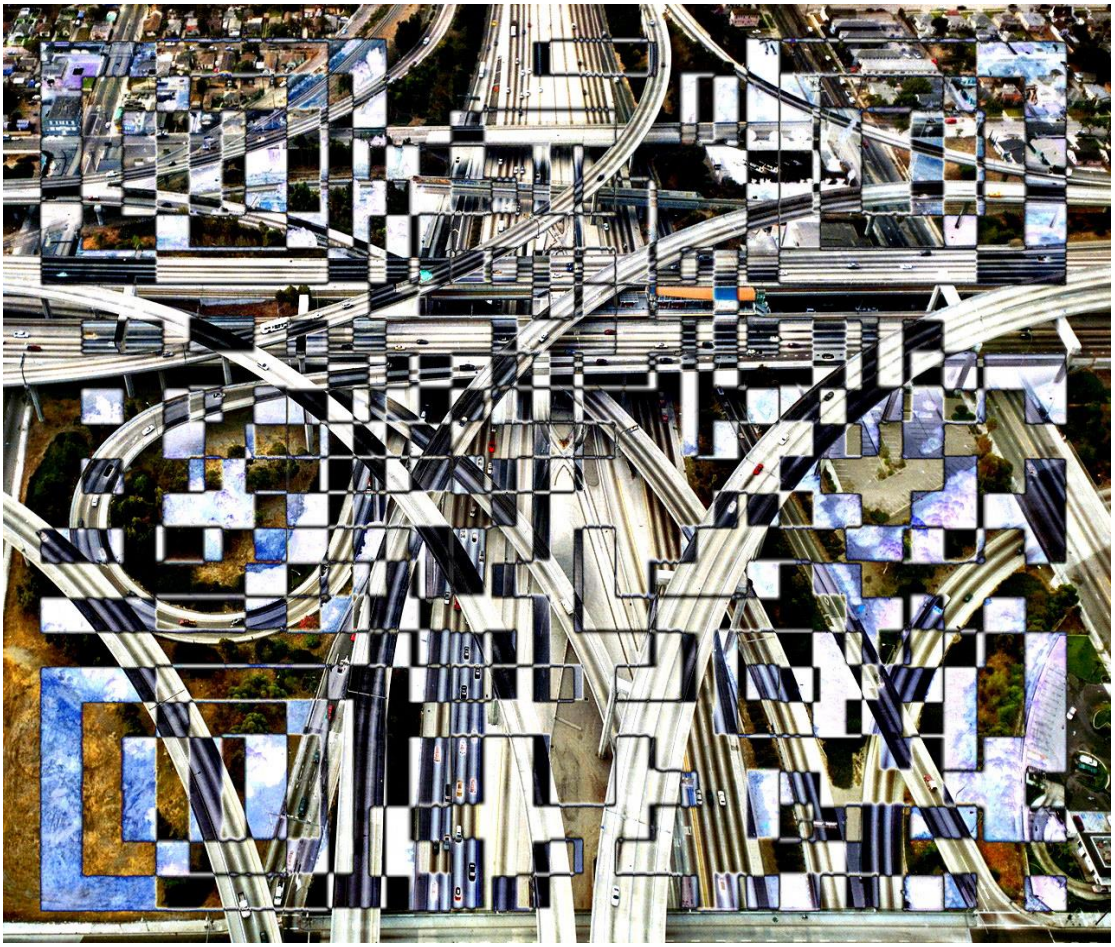

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Abstract

One of the focal points of food trade is the safety of food supply. The food traceability system is an important measure to ensure this. Due to the increasing size and complexity of food supply chains, the quality of food traceability activities is affected by various risks. The objective of this thesis is the identification and analysis of risk factors affecting food traceability. By analyzing the relevant literature in general and the dairy supply chain in particular, this research summarises three main managerial risk factors that affect food traceability. First, the difference in return on investment and profits distribution. Producers and proprietors in order to ensure their own interests, may intentionally alter or change traceability information which can impact on the quality and accuracy of food traceability. Secondly, the poor collaboration and the low transparency in the food supply chain. Normally, enterprises are self-interested and more concerned with their own business' profits, rather than the interests of the entire supply chain. Thirdly, improvement of the regulatory system, the intensity of supervision, and the degree of industry self-regulation are key aspects. In the complex food supply chain, the differences between countries and regions in laws and regulations and the maturity level of industry lead to increasing quality gaps in food traceability activities.

The present study provides recommendations to solve the problems and mitigate the detrimental effects caused by these risk factors. These include the improvement of the distribution mechanisms of revenues, and enhancement of the internal stability of the supply chain. Monopolies of individual companies in one particular stage of the supply chain should be prevented, to ensure that the benefits in each stage will be controlled and distributed more equally. The establishment of a profit and risk sharing chain alliance which will strengthen the collaboration in the different links of the supply chain, should be stimulated. Key parts in achieving this would be strengthening communication, sharing supply chain information, avoiding confrontation and seeking common ground and resolving differences along the supply chain. Last but not least; the introduction of regulations and standards to achieve a unified management system is covering all stages of food production, from processing to distribution all the way to consumption.

Keywords: food traceability, food supply chain, food safety, risk management, managerial risk factor

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Abbreviations

CAC	Codex Alimentarius Commission
DSC	Dairy Supply Chian
EAN	European Article Numbering
EANCOM	European Article Numbering Communication
ebXML	extensible Markup Language
EDI	Electronic Data Interchange
EDIFACT	EDI For Administration Commerce Transport
EPC	Electronic Product Code
FSC	Food Supply Chain
GAP	Good Agriculture Practices
GIS	Geographic Information System
GLN	Global Location Number
GMP	Good Manufacturing Practice
GPS	Geographical Position System
GS1	Global Standard 1
GTIN	Global Trade Item Number
GVP	Good Veterinary Practices
HACCP	Hazards Analysis Critical Control Points
ISO	International Standards Organization
MRL	Maximum Residue Limit
RFID	Radio Frequency Identification
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference
SCRM	Supply Chain Risk Management
SSCC	Serial Shipping Container Code
UCC	Uniform Code Council
WHO	World Health Organisation

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1. Introduction

1.1 Background

With scientific and technological improvements, and driven by a growing population and economic betterment worldwide, food production and distribution systems are becoming increasingly interdependent, integrated, and globalized. At the same time, escalating and heavily publicized outbreaks of foodborne diseases have raised awareness of the need to ensure food quality and safety (Hou 2011). For example, in recent years, many food safety incidents occurred all over the world, such as the mad cow disease outbreak in the UK, in 1986, and it subsequent spread to other European countries. As a result of this, beef products exports dropped drastically. This represented an annual loss of around five billion U.S. dollars, and the induced costs related to the loss of cows amounted to 30 billion U.S. dollars (Bao 2007). Another example, it is the carcinogenic dioxin contamination that affected poultry and cattle in Belgium in 1999. The losses amounted to more than 10 billion euros. Foot-and-mouth disease ravaged Britain in 2001, it led to seven million cattle being slaughtered and the losses of it represented a total loss of eight billion pounds for producers (Hu 2007). In 2003, the avian influenza outbreak in East Asia caused many Vietnamese deaths and about 150 million poultry died from the disease, the economic losses reached up to three billion U.S. dollars (Bao 2007). In 2005, Beijing detected many food products containing a carcinogenic component called Sudan number one. And Chinese dairy pollution events were exposed in 2008 etc. (Zhang 2012; Dong et al. 2011). These incidents prompted the international community and consumers to pay more attention to the food quality and safety issues. Moreover, these examples have highlighted the need to develop and invest in technological innovations that can help trace food consistently and efficiently from the point of origin to the point of consumption.

For a long time, the international general methods of food safety control have included HACCP, GMP, GVP, GAP and ISO9000. These technologies are mainly focused on controlling the production of food and processing environment with the aim to avoid food contamination through potential biological, chemical and physical factors in the whole food production process (Cheng 2012). However, these technologies cannot monitor problems that occur in the circulation process, and have yet to develop accurate and fast means to identify the roots causes of the problem. As a result of this, these processes take longer and are less efficient in reducing the greater damage that be caused to human health, and clear the responsibility of the relevant subjects. Therefore, tracking the entire food supply chain (FSC) from production to consumption is becoming very important. And the ensuring the traceability of products becomes the necessary means to monitor food safety and protect consumer's health (Meng et al. 2009). It is also what consumer's expect from their government and the food industry.

In order to ensure food safety and quality, and the effective monitoring of the factors of food supply chain that can lead to insecurity or low standards, the EU first proposed the concept of food traceability, a post-control technology. In 2002, based on the food safety green paper and the food safety white paper, the EU introduced *The Regulation (EC) No. 178/2002*. The regulation used in food, feed, livestock for food manufacturing and items related to food and feed manufacturing to enforce traceability system in various stages of production, processing and transportation (European Commission 2002). In the same year, the United States released *The Public Health Security and Bioterrorism Preparedness and Response Act*. This act requires the establishment of a record-keeping system in food production, processing, packaging, transportation, distribution and receiving aspect of the supply chain (Huang 2005).

Due to the economic globalization and the expansion of international food trade, the scale and complexity of the food supply chain is also increasing (Kher et al, 2010). In order to ensure the accuracy and consistency of the food traceability, every parts of the food supply chain need to be monitored (Houghton et al, 2008). All the different parts of the supply chain involve different risk factors. These risk factors will cause the deviation of the results, affecting the quality of the food traceability, and at the same time resulting in adverse impact for consumers (Van der Vorst 2006; Golan et al, 2002).

Thus, the analyse and understanding of various risk factors involved in the food supply chain and its associated impact on food traceability will improve the level of food safety and effectively reduce the losses. And also provide plenty of information for the consumers to enhance their confidence concerning the products (Van Rijswijk et al, 2012).

1.2 Problem Statement

The accuracy and efficiency of food traceability is of vital importance in ensuring food safety. But the quality of the food traceability is often affected by many uncertain factors in the complex food supply chain. How can one identify and control the factors of risks involved in food traceability, reduce and avoid the risk of adverse effects, and improve the efficiency and accuracy of food traceability? These are the issues at the core of this research. The risk factors that affect food traceability can be divided into two main aspects, technical risk factors and managerial risk factors (Fotopoulos et al, 2009; Luning et al, 2007). The technical risk factors are the risk factors which occur in the application process of food traceability technology or in the attempt to innovate. For example, the use of Radio Frequency Identification Technology (RFID) does not only require tags but also software and hardware specification that allows the management of the information load through space and time (Costa et al. 2012). Risks using this technology are related to the fact that RFID technology is still recent and its applications to agriculture and food industry still rare, because of technical limitations (Costa et al. 2012).

On the other hand, RFID offers quality food traceability in the supply chain management. For example RFID reader micro-machined metal oxide gas sensors were used in fruit warehouses to monitor climacteric condition during transport and retail (Costa et al 2012). This allows users to monitor conservation stage of commonly traded fruit. The managerial risk factors are focused on the existing and potential risk factors, such as data loss or fraud, warehouse sanitation pollution, transport problems, different standards of food traceability, etc. All these factors can occur all throughout the process of food traceability. This research will mainly concentrate on analysing the managerial risk factors.

1.3 Research objective

The objective of this thesis is according to the identification and analysis of the risk factors affecting food traceability to increase the ability of companies in food supply chain to analyse and control the risk factors, and ensure the accuracy and consistency of the food traceability. The study consists of three parts:

- A review of the food supply chain, food traceability, risk management and food safety risks.
- The identification and analysis of the risk factors affecting food traceability in the specific food supply chain. For example, the dairies supply chain.
- To elaborate detailed, key recommendations on food traceability enablers.

Research questions

Based on the research objectives, one general research question and a series of sub questions are defined. These questions constitute the framework for the research.

The general research question is:

What kind of risk factors affects the quality of food traceability in the food supply chain?

The sub research questions are:

1. What are the main characteristics of food supply chain?
2. What are the key features of food traceability?
3. What risk factors impact food safety?
4. What risk factors impact food traceability?
5. What lessons can be learnt from the dairy supply chain?

Research framework

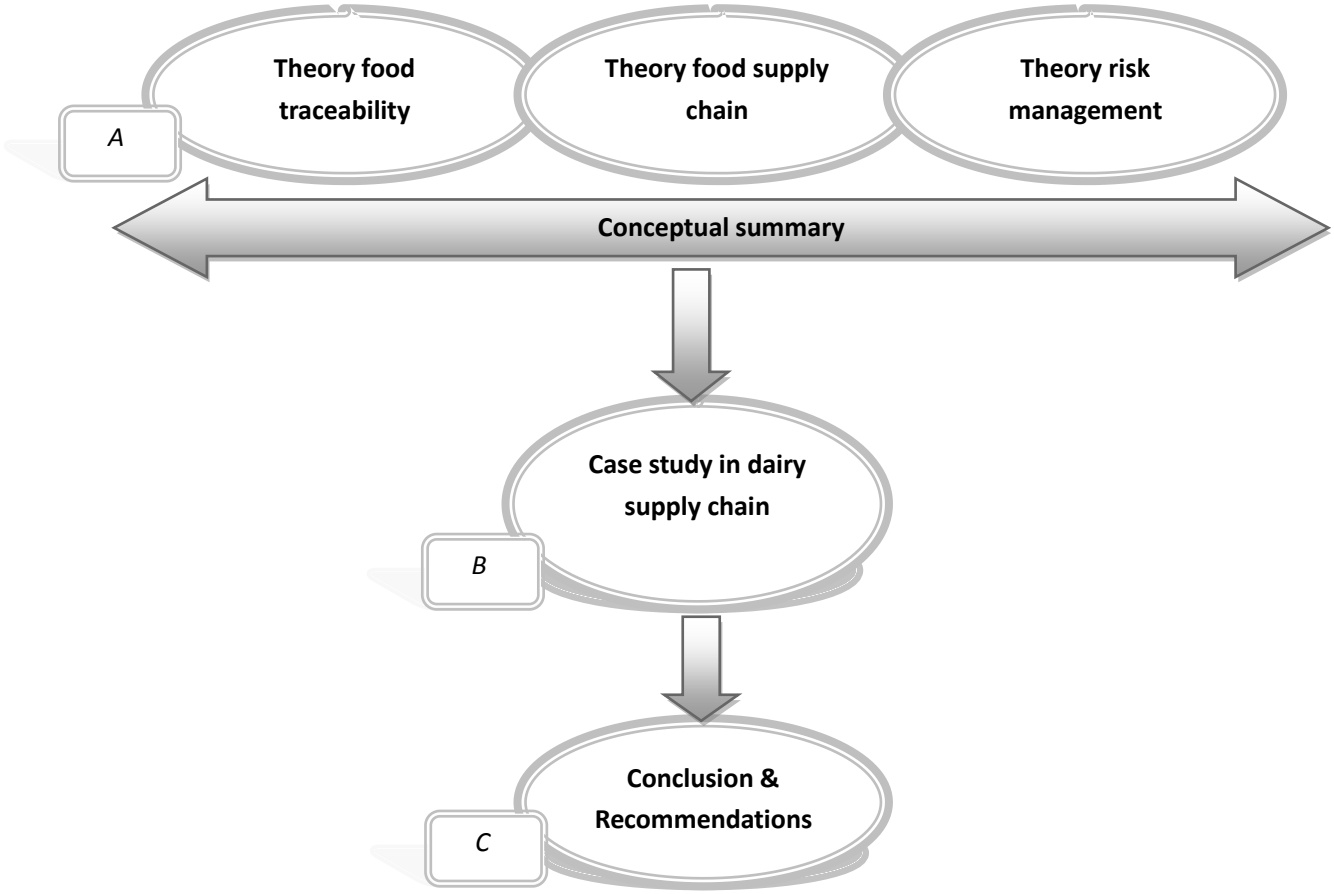

Figure 1 Research framework

In part *A*, a review of the existing literature on food traceability in the food supply chain is laid out. This review is based on the existing theories concerning supply chain risk management and the related management disciplines. Following the literature study, in part *B,* a case study is analysed and considers the risk factors involved in the specific supply chain. In part *C*, based upon the case study and theories, a conclusion will be drawn. Finally, recommendations for risk factors of food traceability will be given.

1.4 Methodology

Literature research is used to capture the theoretical information about sub objective one and two. In order to deeply understand overall status of food traceability and food supply chains. The relevant literatures with respect to food traceability and food supply chain published in academic journals, thesis and books are essential. Different databases have been used to find appropriate literature, such as Google Scholar, CAB Abstracts, Scopus, and OvidSp. Moreover, the information related to general literature regarding supply chain management (SCM), food safety, food traceability and supply chain risk management (SCRM) are necessary complements.

1.5 Thesis structure

This thesis research consists of an introduction (Chapter 1), a theoretical framework (Chapters 2), the case studies and results of the analysis (Chapter 3), a discussion, conclusions and recommendations (Chapter 4), and references.

Chapter 1 gives an introduction to the research. Also, the problem definition, the research objective and research questions are outlined in this chapter. Chapter 2 is about the theoretical background. A general description of the food supply chain is done and the structure will be presented. In this chapter, the various theories and information about food traceability is also described. These studies will guide the analysis in the next phase. Risk management and supply chain risk management are used to analyse the risk factors and their impact on food safety. In Chapter 3, based on the literature research presented in the previous chapter, a specific case study will be analysed. Furthermore, it will help us draw conclusions and recommendations. The analysis of results of managerial risk factors under different link of dairy supply chain are shown and discussed in this section too. Chapter 4 gives a discussion, conclusions, and recommendations based on this research. Moreover, it will also give some suggestions for further study.

2. Literature study

2.1 Food supply chain

Christopher (1992) defined a supply chain as: “a network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumers”. Food supply chain is proposed on the basis of the general supply chain. Den Ouden et al. (1996) believe that the FSC management is an integrated operation mode for the organizations of agricultural and food production and sales. In order to reduce the logistics costs of food and agricultural products, improve quality, and develop food safety and logistics service level. The food supply chain has for object, food and at its core concerns the food processes and operations involved from the production to the consumption of food. It coordinates the benefits among agricultural production materials suppliers, farmers, agricultural operators and consumers by controlling the logistics, information and capital flows. It is a series of processes from agricultural practices and sideline products procurement to food production, transport, purchase and distribution (Jin et al. 2008).

2.1.1 The characteristics of food supply chain

The food supply chain has different characteristics compared to the general supply chain, because it also concerns food safety.

The supply chain is long and complex

From the first stages of breeding and planting until the final step of consumption, the primary characteristic of the FSC is that it is a long and complex supply chain. It covers five aspects: breeding and planting, slaughtering and harvesting, production and circulation. For example, in the case of production and sale of soft drinks in the United States, the supply chain contains the spice extraction processing chain, corn sweeteners processing chain, beet and cane sugar processing chain, carbon dioxide gas processing, fruit cultivation and processing, compound preservatives production, purified water production, aluminium and steel cans processing, cartons processing, beverage production, transportation, storage, distribution, market research, sales, promotion and retail (Zheng 2008). This shows that the soft drink supply chain involves negotiation, implementation and dealing with a variety of supply chains and providing services all throughout the supply chain.

The enterprises situations are different in the chain

Food safety issues have actually arisen through the industrialization and mechanization of food production, which has been increasingly controlled by a few and dealing with enormous amount of production. For example, the output value of the Chinese food industry reached 1.6 trillion RMB (1 Euro = 9 RMB) in 2004. While, 80 percent of the 60,000 food companies employ 10 or fewer people. The production scale is large while the degree of standardization and access conditions

are low, which is the root causes of the past Chinese food safety incidents (Chen 2005).

The gap between developing and developed countries in regards to management standards is wide. Compared to European and American countries, the access conditions to running a food business in developing countries are very low. For example, only 55% of Chinese food products conform to international safety standards (Zheng 2008). In addition, the developing countries' traceability standards are still underdeveloped. In the meat industry, this means that livestock and later meat is hard to source. But it remains that the biggest food safety threat is the source pollution of the planting and breeding industry.

The proportion of logistics outsourcing is large and the consumption cycle is short in the FSC management

Because food and agricultural products involve a single-value cost, the price tends to be low, especially for those fast moving consumer goods. The producers in order to reduce the costs of logistics will outsource the related business (Bao 2007). The timely requirement of food and agricultural products (especially the fast moving consumer goods) is very high. In order to seize the market, they must ensure the products freshness. This is further complicated when from the production, processing, sales to the final step of consumption, FCS involve many stages. And at the same time food supply chain involve a multi-link operation. In a series of links, each link must be careful and cautious in order to achieve the high quality of the final product. This requires the design and the operation management of the FSC must be efficient in order to guarantee the food quality and safety.

2.1.2 The structure of food supply chain

The food supply chain can be roughly divided into three stages. First is the planting/breeding chain, which includes laboratory research and development, from the raw material input to the output of primary products. Second is the processing chain, which includes the sourcing of raw materials (primary products) and the end products. Third is distribution chain, products through transport, storage and sales to finally reach the hands of consumers (Wang et al. 2006).

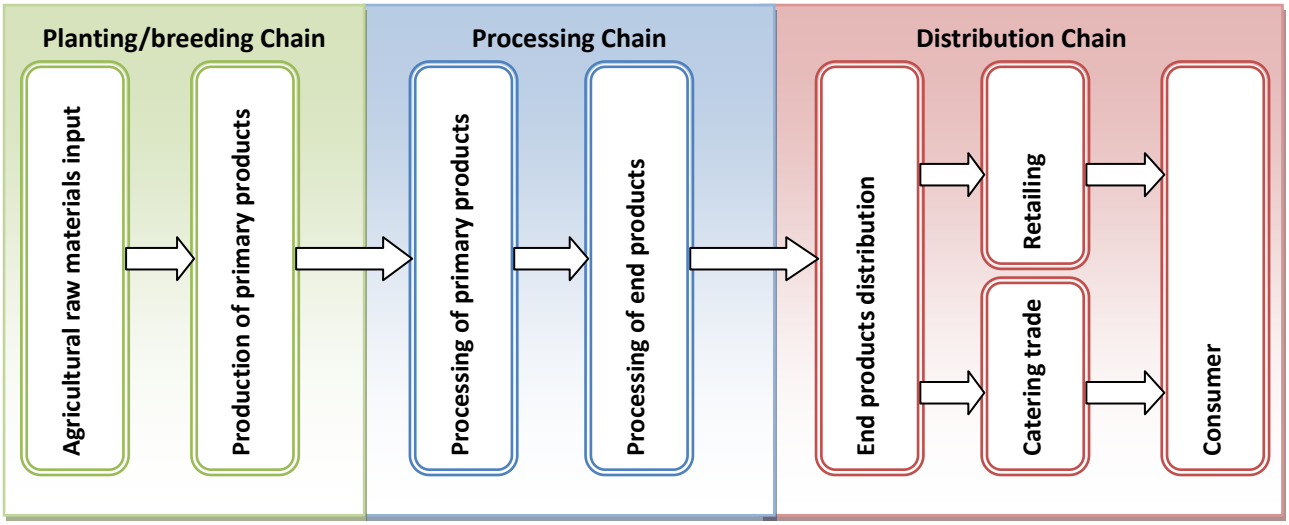

Figure 2 Food Supply Chain (Source： WHO 1996)

In Figure 2, the food supply chain involves three aspects from farm to fork: raw materials production, processing and distribution. The agricultural raw material inputs include fertilizers, pesticides, feed and other inputs. The processing chain mainly includes the processing of primary products, secondary products until the completion of the end products. In the distribution chain, the flow of domestic distribution and international markets is included. The end products mainly use the retailing and catering trade to reach consumers. This food supply chain structure has a clear relationship. No matter which link is problematic, it can easily be traced to the root causes of the problem. It provides a good basis for all food traceability activities.

2.2 Food traceability

Codex alimentarius commission (CAC) and International standards organization (ISO) defined traceability as the ability to tracking history and use (or position) of commodities or behaviours, based on the registered identification code. Traceability is the ability of using the registered marks (this mark is unique to each batch of product. It means the mark and the tracing object have one-to-one relationship. At the same time, these marks are saved as a record) to trace products history (including the background of raw materials, parts and components of the product), status of use, location, similar products and activities (Mo et al. 2010). These quality assurance systems provide traceability of raw materials to suppliers at the generic level but traceability from farm to fork often requires additional measures (Van der Vorst 2006). In practice, “traceability” is the information and documentation record system for food composition and flows in the food supply chain. Food traceability is a two-fold framework which offers practical guidance for the food industry to make their food traceable all throughout the supply chain and exchange information between different actors in the FSC. Food traceability is also beneficial for consumers as it provides them with information, so they can make well-informed choices and also ensure food quality.

Food traceability systems include two levels of meaning (Mo et al. 2010): at the macro level, lies the national food traceability system for food production and regulatory authorities to recall the unsafe food and trace the origin of the food, and communicate with enterprises and consumers. At the micro level, the management system of food safety and quality control for food companies can trace and track the raw materials and the end products.

The establishment of a food traceability system includes food traceability technology system, standard system, information platform, and the promotion and implementation among the food enterprises (Ye 2011). It should cover all aspects of the food chain from primary production to the end consumer. Every type of food can be traced through shared information platforms, forecasting, analyzing and estimating by governments, enterprises and consumers.

2.2.1 General information of food traceability

There are two parts to the process of food traceability (Zhang 2012):

Tracking

Tracking refers to the ability of tracking a specific unit or a group of products through the different steps and between the links, and from the upstream to downstream of the supply chain. In detail, it means that products can be traced from the production base to the processing enterprises to the distribution companies to the retail enterprises to final consumers. This method is mainly used to understand the flow of the product, to determine the final form of the product, and the distribution of the consumer groups.

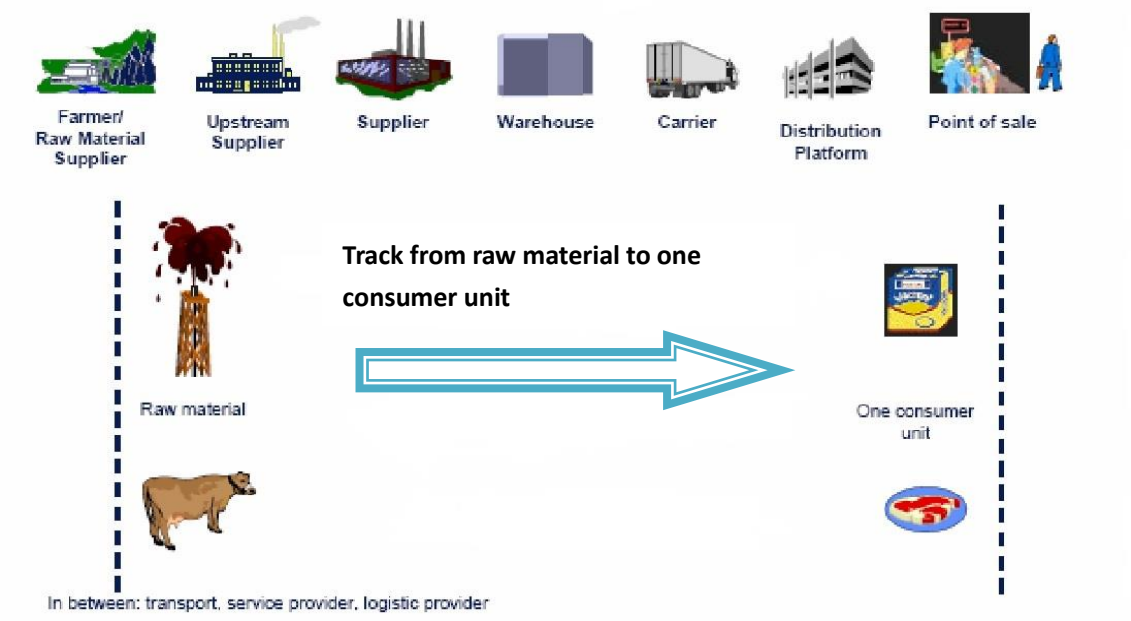

Figure 3 The tracking schematic diagram (Source：Zhang 2012)

Tracing

Tracing refers to the ability of tracing a specific unit or a group of products going through the different steps or the links, and from the downstream to upstream of the supply chain. It is the ability of tracing the origins, purpose and location of an object based on the way of record identification. From the bottom to the top, it means if consumer discovered any quality or safety issue concerning an item of food, they can trace it back to the supply chain and determine the origin of the problem. This method is mainly used to the product recall, to find the reason that caused quality problems, and to determine the origin and characteristics of the products.

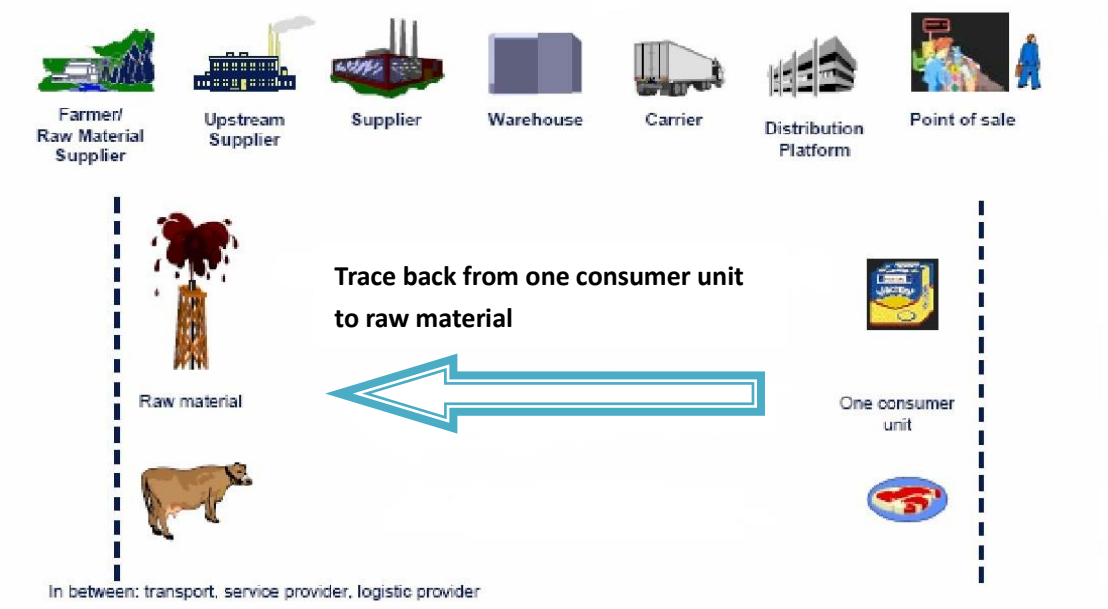

Figure 4 The tracing schematic diagram (Source： Zhang 2012)

The UK Food Agency pointed out that traceability in the food supply chain has the following functions: emergency treatment for food safety accident, control the food residues, assess the risk of food safety, and manage the trademark system, fraud, food waste and hygiene of meat products (Zhang 2012). In the different aspect of food production and distribution, the function of food traceability system is different. Based on the different subjects, the function of food traceability includes:

1. Agricultural raw material producer

For the agricultural raw material producers, according to the traceability information according to which their product was recorded, food traceability system can help them reduce the costs involved in the distribution system, to decrease the expense of the product recall, and improve the management of the supply (Elise et al. 2004).

2. Consumers

Food traceability system is closely related to benefiting the consumers. In case of emergency, it can protect food safety by effective product recall. This method can easily avoid the discomfort caused by certain food and ingredients, whether due to

allergies, food intolerances, or habits and customs. In addition, it allows consumers to freely choose their food, which is produced in different ways (McKean 2001).

3. Government

There are several roles the government plays in ensuring the value of food traceability system. Mainly the government influences food quality through rules and procedures and also via inspection (Luning et al. 2007). The government can revoke the food being sold to protect public health. The government is responsible of the implementation of traceability systems and in charge of providing guarantees associated with traceability (Rijswick et al. 2012). Moreover, the government through the detection and analysis can regulate unreliable commercial fraud, such as counterfeit organic food. It can control the human and animal infectious diseases, such as tuberculosis, salmonella, and mad cow disease.

In case of an emergency, it can effectively control the problems that affect human and animal health, such as contamination of land or raw materials. By rapidly identifying the source of disease and the risk of exposure the government can control in a more effective way the epizootics and local epizootic. Through the establishment of a set of rules livestock owners need to comply with by law, the government can more effectively prevent, monitor and control livestock numbers and animal diseases. This means faster intervention responses to outbreak diseases, identification of unknown diseases, and monitoring of trends and development (Tompkin 2001). This has major impact on the main duty of the government in ensuring public health and safety. For example, in the last two years, in the USA, foodborne disease led to more than 1,500 outbreaks and 23 deaths, according to the US Centers for Disease Control and Prevention (CDC). Hence food traceability could avoid compromising the health – and even lives of millions of people worldwide.

4. Food producer

For the food producer, food traceability system is part of a complete industrial production system. The establishment of a food traceability system can propel the entire production process to obey the relevant laws and regulations. The use of traceability technologies, such as barcode technology, RFID and etc. In order to protect the company's trademark and reputation, in the event of an unsafe or irregular product, rapid action is required to remove it from the sales. That is a stopgap when dealing with the product's quality or food safety incident. It can minimize the scale of food recall, and reduce the cost of repaired or adjusted products return to the market at the same time.

Food traceability systems can also help find out the underlying problems between production and its relevant obligations. Food traceability systems can protect the "identity", or standards of certain products, such as non-genetically modified soybeans and other ingredients. It can minimize the scale of infectious diseases in livestock, and effectively prevent the food supply chain from the contamination of

animal disease. It can ensure the quality of meat products, livestock, and consumer's confidence. Based on the mode of production, food producers will sell different products on different market mainly because food traceability for example, raises consumer's awareness and ability to trace back the origin and quality of their food and are more likely to hold companies accountable for any defect in the product quality (Linus 2003). Furthermore, it can help diagnose problems linked to the production and determine who is liable for this problem. This can help facilitate recall for manufacturers of final products, because while they are still responsible for the recall, with food traceability, and the availability of complete record of ingredients, they might be able to ask for indemnification from responsible third parties (Linus 2003).

An example of the ways in which food traceability systems can help government in ensuring quality food, avoiding disease outbreaks, addressing the risks to and protecting public health. At the end of December 2010, in the North Rhine-Westphalia region of Germany, a chicken farmer found out that the animal feed was contaminated by dioxins. Then the contaminated feed was discovered in other states soon after that. In order to prevent these harmful products to enter the consumers market, the German Ministry of Agriculture announced they were temporarily shutting down more than 4,700 farms, which accounted for about one percent of the total number of farms. More than 8,000 chickens were forced to be slaughtered, and they prohibited those contaminated farms to sale their poultry and egg products. In early January 2011, the perpetrators' company was formally charged. Other damaged farms proposed a civil compensation, which amounted to about 40 million to 60 million euros a week (Ye 2011).

Based on the effective traceability information of the products, the company, which were guilty were soon identified after the incident, and cleared the flow of contaminated food. The food traceability system informed in a timely manner the national management department to trace back in the consumers market the contaminated products. In this case, German identified the contamination source, and food traceability was used as a tool by the government to clearly understand the flow of contaminated products, which tool less than a month. However, a similar incident occurred in Belgium, in 1999, and because they were lacking useful traceability information and technology, the investigation took more than four months and caused huge economic losses. This shows that food traceability has a significant impact for food safety in economic terms and to ensure public health.

2.2.2 The types and trends of food traceability

According to the degree to which products are linked to the supply chain, the food traceability can be divided into: national sources traceability, retailer traceability, processor traceability, farm traceability and complete traceability (See Table 1).

Table 1 The types of traceability system

Type	Description
Complete traceability	From the retail to the farm stage, including the genes of livestock, feeding products and production system etc.
Farm traceability	Can identify the original farm or source of a single product, but cannot help trace back to the original production component.
Processor traceability	Can identify the origin processor of a single product, but cannot trace back to the original producer.
Retailer traceability	Can identify the origin retailer of a single product, but cannot trace back to the original processor.
National sources traceability	Can identify the origin country of a single product, but cannot trace back to the original retailer or processor.

Source: Liddell et al. 2001

This classification can provide the appropriate depth of traceability system for different food safety issues. For example, the prevention of mad cow disease need to be traced back to the animal feeds, only complete traceability system can meet the requirements. As the animal tuberculosis prevention only needs to be traced back to the farm operation, the farm traceability system is able to meet the requirements; in this case there is no need for complete traceability system. It can reduce the costs of traceability. The ideal system in this classification is complete traceability. It is a thorough tracing for the end product from the farm to the retail stage. But this system requires a large capital investment and data devices, so the cost is high. It is not very common to see this system applied in practice. The batch traceability system currently is the most popular in the United States and Europe. The traceability system includes two parts. In the first part, the raw materials can be traced from the processing company to the farm. In the second part, the products can be traced from the retail to the processing company. The tracing for the second part can be achieved by setting up a batch number of the daily output, thus to tracing a smaller batch can be achieved by subdividing the production line. The advantage of it is the optimal batch size is determined by the market. If the batch size is too large and caused the high cost of the recall, the manufacturer will automatically reduce the batch scale (Dong et al. 2011).

The traceability system was first used in 1997 in the European beef industry. Now, after 15 years of development, the following trends can be highlighted (Dong et al. 2011):

- Traceability covers a wide range of products. Food traceability systems appeared in the beef industry after the mad cow crisis, and then gradually extended to other meat sectors, dairy products, aquatic products, vegetables, and other industries. Currently, all the food and agricultural products that are sold on the EU market must be traceable.

- The degree and accuracy of food traceability are higher and higher. Some EU

countries are actively promoting the complete traceability system, such as Denmark, as one of the world's major pork exporters is trying to promote the complete traceability system in the whole country.

- The traceability technology is improving. World's traceability technology is developing from the ear tag methods to the bio-molecular techniques and the electronic and information technology. Canadian cattle industry installed radio frequency identification (RFID) reader before the end of 2011 in all the country's 250 auction market to track the arrival and departure of the cattle. In addition, a high accuracy rate technology of iris recognition is planned to be used in the near future. The technology development will improve the implementation and extension of food traceability system.

- The traceability system will become the new standard for the international trade. As more and more countries integrate traceability system into the policy of food safety, it may become the new trade barriers or standards in the international market. For example, *The Global Traceability Standard*, include the most versatile traceability standards in the global business currently, with the most comprehensive technology, detailed content and full intellectual properties.

2.2.3 The technology and management of food traceability

The traceability system is the information and documentation record system for food composition and flows in the food supply chain (Meng et al. 2009). Therefore, the traceability system is essentially a set of information management system to track food, feed, food producing animals or substance that will be used for consumption through all stages of production, distribution and consumption. To achieve the information integration and sharing processes, food traceability include information identification, collection, transfer and associated management in all stages of the food supply chain The general food traceability technologies include instruments to help collect, record and exchange information, and also includes logistic tracking technology. To help identify batches or units of ingredients and products, identification technologies are used, which comprises machine readable labels, which can be scanned, identified and recorded automatically in the information system. These in turn help to identify objects that move, like pallets, packages and units of products. To provide links to history of the products and its origins, linkages to all data collected is integrated as part of the system (Zhao et al. 2007). For example, once a unit or batch is labelled, the information is recorded and it can therefore be used to provide the information on the links between the products and the origins of its ingredients. This information is related to the path it has followed through the chain, from production to manufacturing, distribution and retail.

The information identification technology

The premise of information management uses widely accepted standards to identify

information, and then collect and transfer this information. With globalization and its implication (increased links and interrelations between international actors) food traceability must be taken into account in the global flow of information, and must adopt a global standard system for information management (Li 2005). Currently the common identification system for product information identification, collection and transfer in the world is the EAN • UCC (European Article Numbering • Uniform Code Council) system, which has been developed by the Global Standard 1 (GS1). The EAN • UCC system is an opening standard system based on the item's trading code, logistic units, location, assets and service relationships. It correlated with the technologies of automated data collection, electronic data interchange, global product classification, global data synchronization, and electronic product code (EPC) and etc. (such as bar code, RFID) to serve the supply chain. More than 100 countries and a million enterprises have adopted this system in the world (Yu 2010). Therefore, the system has become a practical international standard.

The coding system provides the basis to establish a traceability system and is a standard information identification technology. The coding system includes coding for the participants, trade items, logistic units, location, assets and service relationships in the supply chain. Its coding structure provides a unique, globally recognised identification code in the related field, and guarantees that the identification code is unique in the supply chain. For example, in the process of tracking beef products, it gives a unique slaughter origin code for the beef carcass, which links it to the slaughterhouse and enables to identify the carcass. Furthermore, the product's coding provides the relevant information with the slaughter origin code, such as slaughter batch, date and carcass weight. The computer system is used to transfer the related information from the production stage to the packaging of the end product. At the end of the process, the unique barcode is displayed on the package of the end product. It means the food produced in the same day and same batch may contain a different barcode (Regattieri et al. 2007).

The information collection technology

Currently, the most commonly used information collection technology is the barcode technology. The barcode technology uses barcode symbols, which can be read by a photoelectric scanning device and allows the automatic identification, fast and accurate input of the information onto the computer. This technology allows data processing in order to achieve the purpose of automated management (Vitiello et al. 2001). The barcode technology combines computer and information technology, set coding, printing, identification, data collection and processing in one piece. The coding system can play an important role for governments in ensuring public health and safety. A concrete example of its possible application and use is the case of the contaminated milk in the Netherlands, which occurred in 2004. National authorities found a high level of dioxin in milk, and using the bar code system was able to trace back the origin of the contamination trough the chain. The source of contamination was rapidly identified to be the clay that was used in food processing to separate

high quality potatoes from lower quality ones. With the food traceability process and coding it was soon found out that the contaminated clay had also been supplied to several food processing companies in Europe, notably in France, Germany and Belgium. The products were identified and never reached consumers (European Commission 2007). This shows that the food traceability system can help decision makers and local authorities to take timely and efficiency measures in avoid contamination in the food chain before it reaches consumers.

The advantages of this technology include: sample, the barcode symbols are easy to produce and the scanning operation is simple. The speed of information gathering is fast. Using the barcode scanning method to input information is 20 times faster than if using a keyboard. The amount of information collected is important. Using barcode scanning can help collect dozens of characters information, and choosing different type of barcode symbol can increase the character density. The amount of information collected will increase several times. The reliability is high. The error rate of barcode scanning is only one time out of a million and the first reading rate accuracy is over 98%. It is flexible and practical, barcode symbols as a means of identification can be used alone or together with related equipments to achieve the automatic identification. This technology can also be combined with other control devices to achieve the automated management of the whole system. Meanwhile, it is also possible to use keyboard input when lacking automatic recognition device. Free to use, scanning device and barcode symbol can be used in a vast array of situation, greater with the use of the OCR (Optical Character Recognition). The device structure of barcode symbol identification is simple and easy to operate and the costs of promoting of the use of barcode technology are low (Hu 2007).

RFID is a non-contact automatic identification technology. It automatically identifies the target by the radio frequency and access to relevant data. RFID allows the identification work without human intervention, and it can work in a variety of bad environments. RFID technology can identify fast moving objects and can also identify multiple tags, the distance of identification from tens of centimetres to several meters. According to the way of reading and writing, it can input thousands bytes of information, and also has a very high level of confidentiality (Zhang et al. 2009). The basic RFID system consists of tags, readers and antennas.

In the applications of food traceability, RFID tags are more convenient, safer, and offer more transparency. For example, the producer added RFID tags on food products and raw materials, and input the basic information such as place of origin, production date, storage methods, and method of eating. In the next step, the products from the place of origin to the food processing company, those companies will input the processing information on the tags. Then the department of quarantine will input the quarantine information onto the tags. In the warehouse the storage information will be writing on the tags. All throughout the different steps of the process (from the warehouse up onto the market) information is inputted.

Finally when the food reaches the consumers' table each link in the food supply chain can be traced (Conill et al. 2002). However, RFID technology has not a mature and uniform standard throughout the world, and its cost is still high, so this technology is still not widely used for these reasons.

EPC is a new traceability technology, which aims at improving the level of logistics and supply chain management, and reducing the costs. It can give all objects (including retail goods, logistics unit, container, freight packaging and etc.) a unique mark. The EPC system is an advanced, comprehensive and complex system. The main purpose of it is to establish a global and open standard for every single product. There are three parts to the EPC system; the radio frequency identification system and information network system.

EPC system in the traceability of food safety has a great application value. In the production stage, a unique EPC tag is given to the food, product then a scanner will read it, and the product is ready to be taken from the warehouse to the distribution centre. In the distribution centre, reader record all the information from every single product and tray, also realized the commodities inventory management. When food shipped from the distribution centre to retailer, whether in the store or in the warehouse, the reader will record the information again from the commodities. In the last stage of retail, all product information will be read and written down, and then the whole process of traceability is done. The efficiency of this technology is very high. Currently, about 90 end users and 75 system integrators in the world are testing the EPC system.

The information exchange technology

In order to achieve fast, accurate, low-cost, high-efficiency exchange of electronic data information between the trading partners, GS1 developed EDI (Electronic Data Interchange) global standards. It consists of the EANCOM (European Article Numbering Communication) and ebXML (extensible Markup Language) two pats (GS1 China 2011；Yu 2010).

EANCOM is based on the coding system of EAN • UCC system (Global Trade Item Number, Serial Shipping Container Code, Global Location Number, etc.). It is the application guide of EDIFACT (Electronic Data Interchange For Administration Commerce Transport) standard of the United Nations, and it was introduced after simplified by GS1. The EANCOM provides clear definitions and descriptions, which makes the application of EDI more simple and convenient. EANCOM has a broad impact on the global retail industry and has been extended to the field of finance and transport.

EbXML provides a standard for the exchange of businesses information via the internet. The ebXML message standards developed by ISO all use the standard code, such as GTIN, GLN. No matter the differences about the type of soft ware and hard

ware of the trading members, the data still can be integrated in a timely manner, efficiently and accurately and then exchanged on the internet.

The logistic tracking technology

The Geographic Information System (GIS) and the Geographical Position System (GPS) systems provide an accurate tracking record of the logistics and process of transportation (Wang 2005). GIS is based on the geospatial data, using the geographic model analysis method, to timely provide a variety of space and dynamic geographic information. It is a geographic research and geographic decision-making services computer technology system. GPS is an advanced navigation technology, which consists of three subsystems space satellite system, ground surveillance system and user reception system.

GPS is mainly used for real-time acquisition, positioning the geographical coordinates of the target point. GIS can store, analyze, process and output the spatial geographic information by the support of computer technology. GIS can be used to manage and apply the coordinate location data obtained from GPS system. GPS can quickly and accurately collect data from GIS and also provide real-time object monitoring for GIS. In the process of logistics and transport, GIS / GPS technology not only can give a real-time tracking and monitoring to the transport vehicle, but can also monitor and adjust the temperature of the vehicle. This technology is based on the status of real-time tracking and calculates the optimal logistic route, navigate the transport equipments, reduce the run time, and decrease the operating costs (Zhou et al. 2010). Therefore, GIS / GPS technology can track and record the entire logistic process. It is the information infrastructure of food traceability system.

Implement the food traceability system also requires the participation and cooperation of all supply chain, along with the relevant technical side. It will not be able to implement the tracking and tracing of activities when missing any link. This requires effective management for production, processing, transportation, distribution, sales and other aspects of the supply chain, to ensure that the information in every links is standard and accurate. Safe and fast transfer of the information from one link to the next link can realize the tracking for product and also establish the good foundation for further tracing. The characteristics of good food traceability systems also include (Meng et al. 2009):

A complete regulations and laws, and normative enforcement

A sound legal system is the basic of food safety and the guarantee of the safe operation of the supply chain. A legal framework, which covers all food categories and food supply chain can provide a reliable basis for the formulation of the regulatory policies, testing standards and quality certification. For example, the EU's general Food Law, which was applied in 2002, makes traceability compulsory for all food and feed businesses. All food and feed businesses are required to identify where their products have come from where they are going (the "one step forward,

one step back" principle). Producers are also strongly encouraged to keep track of the volume or quantity of a product, the batch number and a more detailed of the production (e.g. whether it is raw or not) (European Commission 2002).

Science-based traceability system

"Science-based" traceability is one of the basic principles of food safety management. Every development of laws, regulations and standards about food safety must be maximized based on scientific theories. In some aspects it is difficult to determine food safety because of the restrictions at the level of scientific development. Hence it is necessary to ask for the opinion of experts to increase the scientific value for decision-making. In this respect, substantial investment and sufficient financial resources in food safety research are needed to guarantee the development of the food research institutions and further scientific knowledge about food safety.

Integrated management and monitoring for the entire process

The integrated function and management is a significant feature of the quality food supply chain management. In developed countries, the food safety regulatory system gradually tends to adopt the mode of integrated management, coordination and operation. Many countries have centralized food safety management into one or several departments and by doing so have increased the interdepartmental coordination efforts in order to improve the efficiency of the food safety management (Hou 2011). Monitoring for the entire process is an important principle of the quality food safety management. Each link of food production, from processing to distribution, sales and consumption imply potential safety issues. Only by supervising the entire process, "from farm to fork", can ensure public health safety in terms of food. Before the production, it needs a strict control the inputs of production and processing, especially the agricultural production inputs, such as pesticides, feed additives and animal vaccines. During the production, develop HACCP or other methods of production regulations to guide the food production, in order to minimize the harmful substances of food. After the production, it is necessary to emphasize the education about the knowledge of food safety and hygiene to consumers, and enhance public awareness about this subject. Meanwhile, an advanced foodborne disease monitoring system can play an important role in food safety management.

This integrated food traceability system is used in tracking animals crossing borders for example in the EU. In April 2004, the EU introduced the TRAde Control and Expert System (TRACES), which provides a database with information on animals crossing borders within Europe and third countries. This shows that in the event of a disease outbreak all potentially affected animals can be quickly identified and authorities will have the tools to take appropriate measures (Huang 2005). Existing traceability systems differ in scope, depth and precision, and according to the size and interests of the invested business. Therefore, there is an urgent need to look at ways for the public and private sectors to cooperate in order to strengthen and

clarify traceability standards and management of these systems. Furthermore, cooperation or alliances between the private and public sector would serve consumers in helping to verify that all food products comply with policies and regulations as determined by governmental agencies.

Complete standards and efficient measures

Compared with the laws and regulations, food safety standards are more directly needed to ensure food quality and safety. Develop strict standards in all aspects of food production, distribution and consumption is imperative. Equally important are restrictions and sanctions for the sale of substandard food products. In the early 1980s, Britain, France, Germany among other countries adopted international standards concerning food products are more than 80%, some standards for specific food even higher the level of CAC standards (Ye 2011). Apply standard management is one of the most effective means to regulate the production behaviour, improve product quality and ensure food safety. The primary function of the government in food safety management is developing food safety standards and enforcement of these standards. These standards include the general prohibition on adulterated food and the specifically limitation about the amount of chemical residues in food. It also includes the standard requirements of product and the procedures of processing.

Open information and public participation

In the process of food supply chain risk management, the exchange and dissemination of risk information is very important. The government must pay attention to the public's right to know, to strengthen the openness and transparency of the food safety system construction and food safety management, and establish an effective FSC safety information system. Governments regularly release useful information, such as the testing result of food market, the recall information about substandard food, and the motions of management department, to enable consumers to understand the real situation of food safety, and enhance their ability for self-protection.

2.3 Risk management

Sitkin and Pablo (1992) define risk as being “the extent to which there is uncertainty about whether potentially significant and/or disappointing outcomes of decisions will be realized.” There are many different definitions of risk, but risk is mostly contextualized within the area of decision making (individual or organizational), (un) predictability and potential loss. Risk management covers many areas, including policy risk, market development risk, production risk, financial risk, operation management risk and investment risk.

The process of risk management has two parts: before the occurrence of the loss and the management of after the occurrence of the loss (Ma et al. 2005). The objective of the risk management process before the occurrence of the loss is to

avoid or reduce potential accidents, and also includes saving on operation costs and decreasing anxiety Levels. The objective after the occurrence of the loss is to try to restore the loss to the state, which includes the maintenance of the survival of the enterprise, continuing production and provision of services, ensuring stability of income, and the continued growth of the production and a certain level of social responsibility. The effective combination of both parts constitutes a complete risk management objective.

How to deal with the risks is at the core of risk management. A basic principle of risk management is getting the maximum protection at a minimum cost. There are four methods to deal with the risks (Hu et al. 2005):

Risk avoiding

Risk avoiding includes a complete risk-averse approach, which is to cut off the sources of risks. It means abandoning or terminating the collaboration of the supply chain, or change the environment of cooperation, to avoid the impact of external accident on the enterprise. Although this method can fundamentally eliminate potential risks, it obviously includes a lot of limitations as well. Because not every risk is able or should be avoided, sometimes it means the loss of potential profit making opportunities.

Risk prevention

This method is based on risk identification and assessment, and takes preventive and control activities to the related risk, to reduce the opportunity and damage of the loss. Risk prevention involves a comparison between current costs and potential loss. If the potential loss is much greater than the current costs, it should take into account this method to prevent the risk, such as building water conservancy projects and construction of shelterbelts.

Risk transfer

Risk transfer is a method, which implies the transfer of all or part of possible risks. This method is the most effective risk management tools with the widest range of applications. There are two types of risk transfer: insurance transfer and non-insurance transfer. The first one refers to buying insurance from the insurance company and transferring part of the risk of loss to the insurance company. The second implies the transfer of risk to the outside enterprise of supply chain; this means that the risk is shared by the entire supply chain enterprises.

Risk absorption

This method implies that all potential risks are taken care of by the company. They may know the existing risks, but are willing to stand the chance for huge economic benefits in return. Another reason that is they cannot avoid it due to the fact that it is a system risk of the supply chain. The only way to solve this is to absorb the risk by all enterprise in the supply chain, and it is cheaper than buying insurance. Risk

absorption is normally used to deal with the risk of small occurrence probability and which imply low level of losses.

In the supply chain, the risk often transfers from one enterprise to another enterprise, and this has a magnifying effect. Thus, the collaboration in the supply chain for risk management is absolutely essential (Hallikas et al. 2004). Some risks can only be mitigated and not eliminated, such as climatic disaster. Therefore, the endurance in the supply chain is necessary. The method chosen of risk management is a scientific based decision. It should be based on the full understanding of the internal situation and external environment of the supply chain, but also pay attention to the applicability of the method and effect. Generally, the choice of a risk management method is not isolate, and it is the combination of several methods.

2.3.1 Supply chain risk management

Supply chain risk management combines risk management into SCM. According to Brindley (2004) "Supply chain risk management is at the intersection of supply chain management and risk management and has for objective to help organizations handle the uncertainties and risks involved in the supply chain". Especially in the food chain, the quality control and the ability to track and trace are critical (Fearne et al. 2001).

SCRM is becoming a critical SCM discipline, especially considering that supply chain offers greater exposure to new risks caused by changes of outsourcing, lean manufacturing and Just-In-Time inventory. Focusing on the supply chain, SCRM cover all aspects of risk management in the supply chain. Waters (2007) believes that "the overall aim of supply chain risk management is to ensure that supply chains continue to work as planned, with smooth and uninterrupted flows of all materials from initial suppliers all the way through to final customers". This definition does not purely focus on risk prevention but also on the supply chain working as planned, in fact, which is the key target of SCM.

SCRM connected strongly and closely not only with SCM but also risk management. Both SCRM and risk management have the same goal, that is, to help organizations understand, evaluate and take actions on the different risks, in order to reduce failure and sustain successful business. The difference is that SCRM focuses on the risks in the supply chain and the failure and success of the whole supply chain while risk management stresses the risks of one individual organization, as is the case in general risk management.

2.3.2 Categories of supply chain risk

In or between the different links of the supply chain, risks can be detected and bring a huge influence on the different members of the supply chain. It is therefore very critical to know where in the supply chain the risks exist and what their causes are.

Different ways to categorize risks are described in the risk management section (Brindley 2004; Christopher et al. 2004; ISO International Standard 2007). One of the common characteristics of the various categorizations is the distinction between external and internal risks. The risk categorization of Christopher et al. (2004) is the most widely used and accepted in SCRM. See Figure 5.

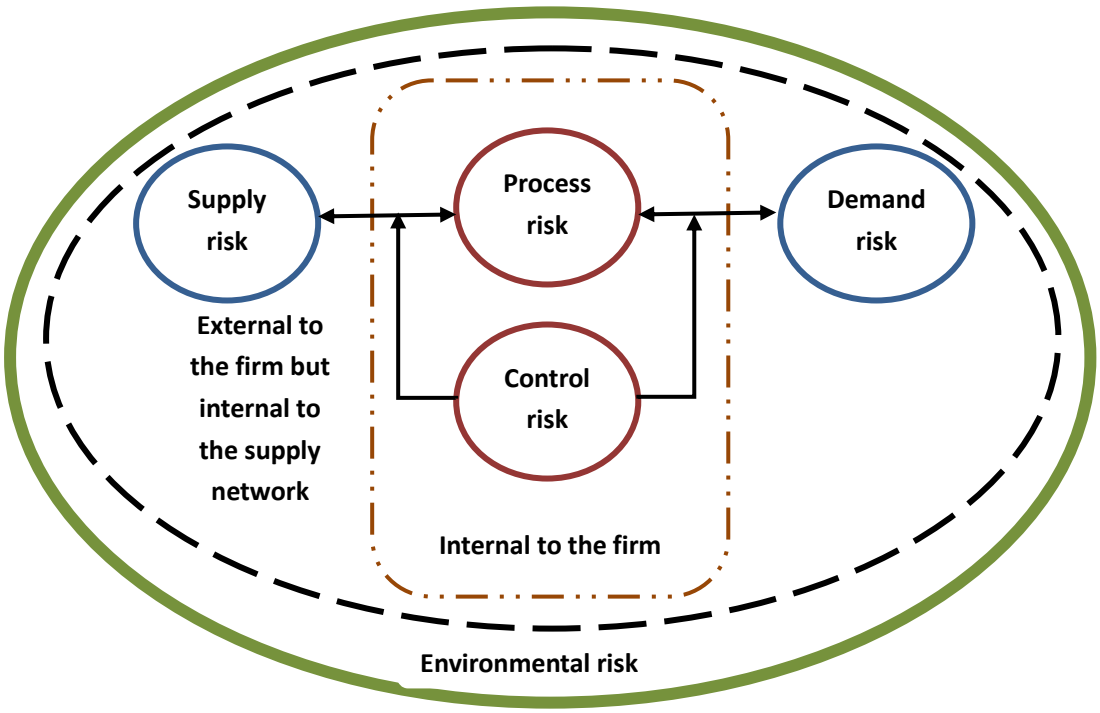

Figure 5 Sources of risk in the supply chain (Source: Christopher et al. 2004)

Internal risks

Further breakdown of the internal risks expose two internal risks, including risks that are internal to the firm and risks that are internal to the supply network. Supply chain risks that occur internally in the firm can be much diversified. Christopher et al. (2004) split internal risks into control and process risks. This internal element can also be compared with the "make" element of the supply chain operation reference (SCOR) model (Christopher et al. 2004). Supply chain internal risks are risks that occur between the walls of the firm under the influence of more than one supply chain member.

Risks that are external to the firm, but internal to the supply network are the risks occur in upstream or downstream of the chain. Christopher et al. (2004) call these risks the supply and demand risks. These risk areas can be compared to the "source" and "deliver" elements of the SCOR model.

External risks

External risks are defined as the risks that are outside of the whole supply chain network. Since these risks are not easy to predict and avoid, risks in the external environment are not included in the development of the SCRM method. External

risks are important risks that exert an influence on the supply or demand side of the supply chain or on the internal operation of the focal firm.

2.3.3 The risk factors impact on food safety

According to the WHO (1996) definition: food safety is a guarantee that the intended way to produce and use food will not cause damage to consumers. According to the popular explanation the food safety encompasses two aspects. On the one hand it concerns the nutritional value of food, and the aspect of quality. People care more about the quality aspect in their daily lives, such as food spoilage, the nutritional value of food, etc. On the other hand, it is the problem of the natural and pure attribute of food that has been changed by human in the process of production, processing, transportation, storage and sales (Wang et al. 2004). These problems are concerned by the activities of food traceability.

The following information concerns the food safety risks that have been identified in the literature:

Classification by the different segments of the food chain
The risk factors can be defined as (Xie et al. 2009): hazards in the food ingredients (such as natural toxic substances, pesticide residue, veterinary drug residues, harmful metals, environmental persistent organic pollutants, and biological contaminants), food processing hazards (such as hazards generated by heat processing, safety issues of new technology, safety issues of new resources, the side effects of food additives, processing environment and etc.), contamination of food containers and packaging materials (such as plastic hygiene problems, hygiene problems of rubber products, paint hygiene problems, hygiene problems of other materials), hazards in the food storage and transportation process (such as chemicals contamination, hygiene problems caused by improper temperature, personnel hygiene pollution and etc.).

Classification by the hazardous substances
The risk factors can be defined as (Wu 2003; Jin et al. 2008): microbial contamination hazards (such as bacterial contamination, food-borne parasitic diseases, fungi and their toxins, food spoilage, etc.), chemical pollution hazards (such as veterinary drug residues, pesticide residues, heavy metals and other trace elements, nitrate, nitrite and N-nitrate compounds, polycyclic aromatic hydrocarbon compounds, heterocyclic amines compounds, dioxins, radioactive material, etc.), the dangers of food additives (such as preservatives, bleaches, antioxidants, flavor agents, flavoring agents, emulsifiers, etc.), new technologies, as well as the safety of the food processing.

Classification by the pollutants
The risk factors can be defined as (Xu et al. 2008b): biological pollution (such as bacterial contamination, mold and mycotoxin contamination), chemical contamination (such as pesticide pollution, metal toxic pollution, pollution of N-

nitroso compounds, polycyclic aromatic hydrocarbons, etc.), physical pollution (such as exogenous foreign body, radioactive contamination, etc.).

The above classification methods are basically from the point of view of natural science to classify the toxic and harmful factors that may occur in the food. They constitute the entire content of the food safety risk. In these risks, the main problems affecting the food safety are as following:

1. The problem of food additives

The excessive use of food additives is one of the important factors that lead to food safety issues (Yu 2004). Food additive are necessary basic ingredients in the food production and processing, to ensure longer shelf-time and conservation of the products and are the most important products used for safety. The production of food additives needs a rigorous assessment and toxicological tests, and the value evaluation of ADI (Acceptable Daily Intake). It is safe to use the food additives under the health standard. Correct and rational use of food additives will not contaminate the products, but can also in the contrary safeguard the safety of the food. There is a problem in the use of unqualified food additives in the food additive management. The unclear and substandard label made by food additives producer, and the misuse of industrially produced, chemical products in food production will cause serious impact on food safety.

2. The problem of non-food materials

Most of the non-food raw materials used in food production are industrial additives, non-food chemical materials and industrial chemical products. Those materials can cause harm to human health, such as in the case of “alkaline green” in seaweed products, “Sudan red” in chili products, melamine, “malachite green”, sodium formaldehyde sulfoxylate in milk powder products.

3. The food safety regulations and standards problem

The biggest issue related to regulation and standards of food safety is the incomplete food technology regulations and standards, especially the safety and testing standards. The food safety standard system is confusing because of the development and management of standards, which are based on various departments. Testing standards and food quality control system are two processes that have yet to be standardized. The safety production technology standards and operation standards in food chains make a big difference in comparison with food standards, pollutant limitation standards, and the analysis and testing standards. It is difficult to ensure efficient control of the entire food chain.

4. The problem of primary products and agricultural inputs

This is a main problem concerning food safety issues. Food raw materials come from primary agricultural products, and the key problem of primary agricultural products is the misuse of agricultural inputs. For examples, the illegal use pesticides and

veterinary drugs will easily caused drug contamination of food (McEvoy 2002). The agricultural chemical residues on food can cause the resistance of the pathogens (Butaye et al. 2001; Barbosa et al. 2005). The biological, chemical and environmental pollutants in the primary agricultural products are serious problem (Xu et al 2008a). The EU made a clear and detailed provision for MRL (maximum residue limit) and the use of drugs in food of animal origin (European Commission 1990; Van Petehem et al. 2004).

It is important to base safety measures on risk monitoring, analysis and assessment technology, which can further strengthen the study of primary agricultural products, agricultural inputs, safety infrastructure and application, and food safety management. This is essential in order to discover fast and efficient testing methods and technologies for the research of pathogens, pesticides, veterinary drugs, chemical pollutants in food (Li et al. 2009). For example, the use of biosensors technology can help detect the drug residues in food of animal origin (Franek et al. 2005), then use the evaluation of the data analysis to determine the MRL standards, so that the quality of primary agricultural products in the food chain can be guaranteed.

5. The problem of processing, storing, transporting and environment pollution

The scale, technology, hygiene conditions, transportation and storage capacity, and management of food processing enterprises will have an important impact on food safety. In the food raw material production, processing, storage, transportation, and sales sectors, due to the problems of production and storage technology, it could easily lead to food secondary contamination. This is the potential risk factor of food safety issues (Chen et al. 2008).

6. The problem of application and safety testing system

Enterprise must continue to improve the safety testing and evaluation system for new products, technologies, processes, accessories and raw materials, such as food additives, genetically modified foods, enzyme preparation, food packaging materials and food containers (Song et al. 2009). For example, there are many difficulties that arise from the use of the traditional toxicology test method and risk assessment procedures to evaluate the safety of genetically modified foods. Losey et al. (1999) published an article in *Nature* magazine about the safety problem of genetically modified crops. They argue that the biological food safety issue has become the focus of attention of the international community. Most of the new technology of the food industry use chemical and biological technology. Those food products need a verification and assessment process, and the continuous development of new technologies also brings new issues for the food safety. Those problems need to set up a complete scientific and systemic safety testing and evaluation system (Tang et al 2005).

7. The problem of food safety analysis, assessment, and early warning system

Food safety analysis, assessment, and early warning require setting up a complete system. In order to ensure the system running in an effective way there is also the need to establish a set of technical and procedural rules and regulations, and the good cooperation and communication among every department. In the end, a complete and effective risk analysis and assessment system will be developed.

3. The risk factors impact on food traceability

Food traceability is necessary in order to monitor and track various risk factors, which affect food safety. Based on relevant food traceability technologies, food traceability systems can collect large numbers of data for risk analysis and risk management. It provides timely, continuous and accurate records and information tracking for the food chain. It can predict the reasons of hazards and degree of risk, and also provide a flow and range of polluted products. Food traceability provides the possibility to proceed to food recall. It is an important tool for enterprises to enhance food safety and quality control. In order to ensure the accuracy and consistency of food traceability, it is necessary to study the risk factors that affect the quality of food traceability. A concrete example of the application of food traceability and its benefits is illustrated by the use of the Rapid Alert System for Food and Feed (RASFF). There are 27 member states part of this warning system which allows the traceability and rapid exchange of information in the event of a potential threat to food quality, or feed safety. In the event of such contamination issue, member states need to notify the European commission, which will immediately take appropriate measures to correct the situation (European Commission 2007).

The risk factors that affect food traceability can be divided into two main categories, technical risk factors and managerial risk factors (Fotopoulos et al, 2009; Luning et al, 2007). The technical risk factors are the factors which occur during the application and innovation concerning food traceability technology. Such as the information identification technology, the information collection technology, the information exchange technology, the logistic tracking technology. The application of any new technology requires a testing period. During this period, the authenticity of the food traceability activities is easily influenced, distorted or un-collectable. This will decrease the quality of the results of traceability and increase the risk.

The managerial risk factors are focused on the existing and potential human-centered risk factors. During the process of food traceability, they are locating in the various parts of the FSC. For instance, misuse low quality raw materials, data loss or fraud, warehouse pollution, transport problems, vicious competition, food traceability standards differences, safety awareness, etc. In comparison with the technical risk factors, managerial risk factors are much more complex and more difficult to control. It has higher concealment and subjective, food traceability can be affected in every link of the food supply chain. If a problem occurs, it will result in a great deal of damage for the quality of food traceability (Chen 2005; Zhao et al. 2007). Therefore, this research is based on Figure 2 in the division of the food supply chain, take dairy supply chain as the example, and mainly pay attention to analysing the managerial risk factors.

The planting/breeding Chain

This section, concerns the provision and quality of agricultural raw materials input and production of primary products two parts. As the first stage in the food supply chain, it is the source of food biological pollution. The development of modern industry caused a lot of damage to the environment, and the pollution of this damage began to slowly spread to the countryside. The planting and breeding environment in rural areas is continually polluted by chemical hazards and pathogenic bacterium. The pollution of land, rain, and atmosphere will directly contaminate agricultural production, and the influence of pesticides, antibiotics, growth substance, etc. It shows the biological contamination existed in agricultural production stage (You et al. 2009). Due to differences in the quality of farmers, the degree of attention for contamination of crops, the disease of poultry and livestock are different too. This brings a lot of obstacles to food traceability. For example, When poultry or livestock deaths in the farm, some of them may casually abandoned those corpses at fields or rivers, and do not take any methods of isolation and destruction. It is easy to cause a wide range of cross-infection, and this infection is difficult to be traced back to the source.

The processing Chain

The processing part is an important link for food traceability. The raw materials of food processing enterprises usually come from the separate production organization. From the processing of primary products to the end product, various primary products and auxiliary materials are used in the process and changed the traits. This can lead to cross-contamination of agricultural products, and makes the process of traceability more complex. The way to use food additives, the difference of production processes, and the regulatory hygiene standards will further increase the difficulties of the food traceability activities (Meng et al. 2009). In addition, the collaboration among different enterprises in the food supply chain and the transparency of the production and operation processes are poor. Those man-made factors directly affect the efficiency and authenticity of traceability. For example, because of vicious competition, some processing sectors in order to reduce the costs to use inferior raw materials and tampering the traceability information. This approach reduces the quality of the final product, but it is hard to be traced back to the origin.

The distribution Chain

The food distribution is the last part of the food supply chain and direct link with consumers, and likely to cause the secondary pollution. It is the initial stages of the food traceability. The quality of food depends, partially on transportation and therefore the correct and effective storage equipments and ways of transportation. The development of the food industry leads to the distance between the production process of food and consumers at the end of the chain. Foods often need to go through the long-distance transport, a wide range of sales, as well as multi-channel and multi-link circulation (Bao 2007). This trend has increased the difficulty of food

traceability processes. The shelf life of the food is short. Transportation needs to be achieved in a timely manner, and there are some necessary measures to ensure the produce quality. The end products are delivered to the retail industry and catering trade, and finally reach the consumer's table. At this stage, the quality of enterprise management, the level of storage and transportation equipment, the supervision of the marketing place will all impact the accuracy and efficiency of food traceability. Regarding the consumer links to the food traceability, the consumer limited awareness and understanding of food safety can hinder the extension and implementation of food traceability to a certain degree.

3.1 The risk factors affecting food traceability in dairy supply chain

3.1.1 Basic information and characteristics of dairy supply chain

The research object of dairy supply chains are dairy products. Around the core business to control the information flow, logistics and capital flow. The supply chain starts from the raw milk procurement, to the processing by dairy processers, and is followed by the distribution to the dealer and retailers, such as supermarkets, shopping malls, canteens, and finally the product is sold to consumers. It is a network model composed by dairy farmers (or ranch), dairy processing enterprises, dealers, distributors, retailers and consumers together (Zhang et al. 2010).

This is a value-added chain. The materials in the supply chain are increasing its value in the process of processing, packaging, transportation and retailing. The ultimate goal of supply chain management is to coordinate the supply chain logistics, information flow and customer demand, and realized the balanced state between the maximization of customers satisfaction and the benefits of the overall supply chain. The dairy industry is a special industry, not only does it have a long industrial chain and many links. Its vertical extension involves the primary industry (agriculture and animal husbandry), secondary industry (food processing industry) and tertiary industry (distribution, logistics, etc.). Any quality problems on the link of dairy supply chain will affect the quality and safety of the whole supply chain, and finally affect the consumer’s food safety (See Figure 6).

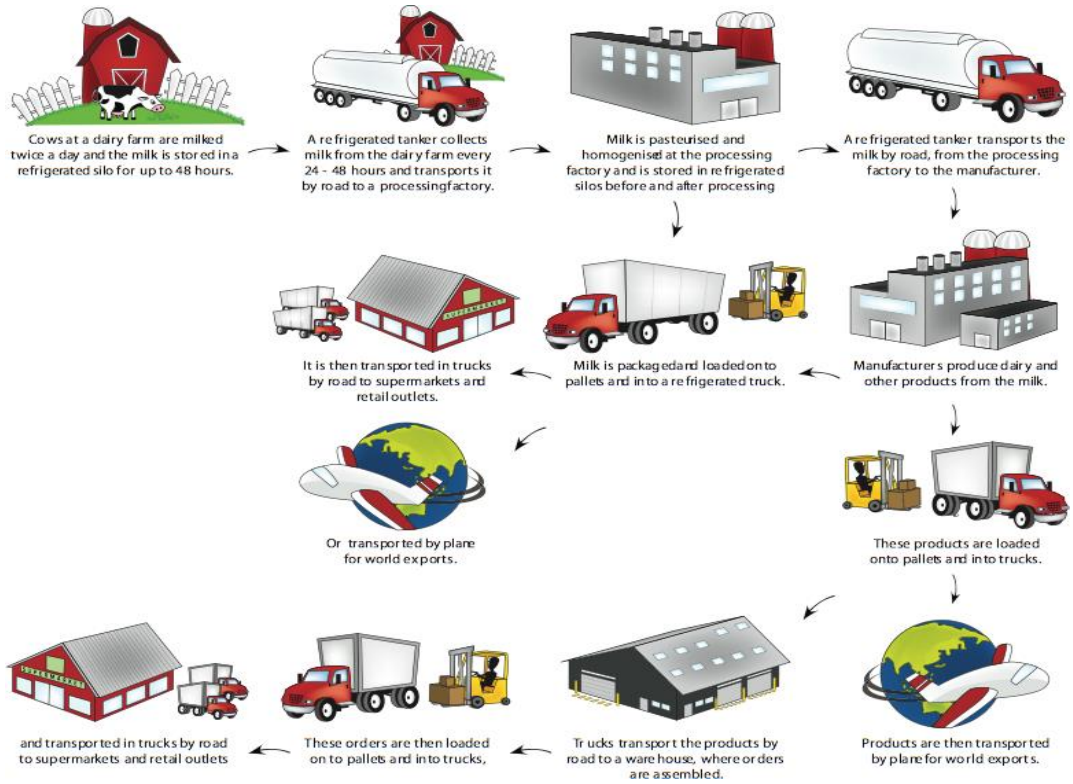

Figure 6 The dairy supply chain schematic diagram (Source: TDT Victoria 2009)

There are two aspects concerning the quality and safety of dairy products. The first one concerns the safety of hygiene. Dairy products cannot contain any form of harmful ingredients to human health, and it will not impact negatively the environment. It should be added that also included in this first aspect of the dairy supply chain is the identification of hazards, and immediate or long-term hazards. This point emphasizes the safety attribute of dairy quality attributes. The second one regards the safety of nutrition. According to the generally accepted standards of dairy products the protein, fat and carbohydrate content in the dairy products must fulfill the requirements. It cannot cause any malnutrition (He 2012).

The main reason to develop the dairy supply chain management is the consumer's requirements to see an improvement on the products available on the market. Dairy supply chains have special characteristics because of the core products it implies (Peng et al. 2012). First, the source of dairy products comes mainly from cattle, but also from sheep and goats among others. The growth of these animals is influenced by natural conditions, the feeding patterns, and other factors, so the production process is volatile, uncontrollable and unpredictable. Second, milk is a perishable product, which is difficult to store. Hence, the required time from production to consumption also require careful handling and control. In order to ensure the quality of the product and optimize their opportunity to sell on the market, the supply chain of dairy products requires throughout the whole process to proceed in a timely manner. This means that at each stage of the process, each operation must be undertaken carefully and cautiously to ensure the final product's quality and safety.

This also means that a highly efficient operation management of the supply chain.

Third, dairy supply chain implies a strict requirement concerning shelf life, and also concerning hygiene conditions in the process of storage and transportation. For example, it requires that at all stages of the supply chain (e.g. raw milk, packaged milk and the final product) satisfy the high hygiene and quality standards. This is also through of the stages concerning the transit time, and the entire cold chain control. The purpose of the "cold food supply chain" is to ensure the quality of perishable goods. It includes technical requirements concerning the transportation system and also the storage places, in order to ensure the quality and safety of dairy products. Fourth, due to the characteristic of dairy products short shelf life, dairy-processing enterprises should pay more attention to the recycling and disposal of products. Rapidly dairy recycling can improve the reputation of the brand, reduce the wastes, and decrease social and environmental costs.

3.1.2 The identification and analysis of the risk factors in dairy supply chain

According to the dairy supply chain structure, the identification and analysis of the risk factors play a role in determining the quality of traceability of the product at each stage of the chain. These risk factors mainly concern six aspects:

Agricultural raw materials input

According to the food supply chain structure, the first step of the dairy supply chain is the cow rearing. This step is an aspect to determining the quality of the first product, raw milk. At this stage, the animal feed, the climate and rearing environment, as well as the cows' health are all factors that will influence the quality of raw milk in different degrees. The main factors that need to be taken into consideration when trying to optimize the products' quality are:

1. Feeds. The residues of harmful substances in feed, particularly a variety of food additives residues; have a great impact on the quality of raw milk. Because of the dichotomy between the cost of feed and the price of raw milk, dairy producers are prone to behave in a way that helps them reap greater benefit but can be harmful to public health and produce low quality products. For example, because of low price on the market and low marginal benefits, some dairy producers have decided to feed dairy cattle with low quality feed. In order to cover up the non-standard behaviors, dairy producers might change or destroy the traceability information about pesticides, hazardous substances, heavy metals, additives and other damageable or toxic ingredients that might have been mixed with the feed. These kinds of activities are problematic because they are misleading or lead to inaccuracy in the food traceability process. Thus the quality of food traceability is affected. This is why the food traceability system makes it mandatory for dairy producers to comply with the "one step forward and one step back" process in the food chain. Once a risk has been identified, producers are required to

immediately withdraw the affected product from the market and, if necessary, recall from consumers. Furthermore, dairy producers are bound by the food traceability process to destroy any contaminated batches, and inform competent authorities of the risk and the action that needs to be taken to solve the problem.

2. Disease control and prevention. The health of herd requires close attention to ensure that they produce quality raw milk, which requires healthy cows. Infectious diseases such as mad cow disease, foot-and-mouth disease have a serious impact on the farmers, their reputation and their economic profits and if the treatment is not appropriate it will lead to farmers' bankruptcy. The records of cow disease, treatment results, as well as the handling of dead cattle all constitute important information in the process of food traceability. Incomplete or inaccurate information management will impact negatively the process of food traceability.

3. Rearing environment. The water quality, the rearing environment and hygiene conditions of the barn all have a direct impact on the cow's health. The rearing environment's facilities, the staff professionalism, the temperature of the barn, microbial content, humidity, disinfection and hygiene standards will directly affect the cows' health. Management standards and monitoring status of the rearing environment have an important impact on the results of the food traceability. The substandard criterions and compliance to these will decrease the risks associated to food traceability. For example, the staff who suffering from an infectious disease, they will make an impact on the health of livestock.

Production of primary products

With the aim to ensure safe and high quality milk products, from raw material production to the point of consumption, processing and handling of all milk and milk products should be subject to a combination of control measures. These measures of agricultural and manufacturing practices should meet the appropriate level of public health protection. Only high quality raw milk can produce high-quality dairy products. The primary product of the dairy supply chain is the raw milk production. The information about the raw milk in this stage such as milk density, proportion of water, milk freshness (acidity), alkaline substances, starch, maltodextrin, urea, bovine mastitis milk, raw or cooked milk, milk protein, heavy metals and pathogenic microbial content need to be clearly recorded. According to the collection and analysis of this real-time information, the timely monitoring and correction of various problems and is essential, this is what is called "real-time management" for the quality of raw milk. The main factors that affect the quality of raw milk at this stage are:

1. The hygiene conditions of infrastructure are important at all stages of production and processing. In the event of inappropriate management, or if cleaning measures are not done in a timely manner for milking for example, it can lead to contamination and microbial contamination. Moreover, high hygiene standards are important when it comes to milk storage, milk transportation equipment and transportation refrigeration facilities because it can also cause microbial contamination and subsequently affect the quality of raw milk. In this process, the evaluation criteria of the management department and the quality of operation and staff effectiveness are the key elements to ensure accurate food traceability. Reasonable staffing and periodic business training can improve the standard of the management efficiency.

   Moreover, dairy producers should ensure that people undertaking and supervising the milking operations and management of the dairy farm are skilled in all the different stages of operations. For example, staff needs to be trained in the hygienic of milking animals, the administration of veterinary drugs, the activities undertaken on the dairy farm in relating to food safety and health and safety practices relating to dairy farm operations. Therefore, serious and responsible work attitude can guarantee the quality of the food traceability in general. As such, all dairy farmers, suppliers to dairy farmers, milk carriers and haulers, dairy product and food manufactures should be part of an integrated food safety and quality assurance management system to ensure good practices and the market of safe, quality assured milk based products.

2. The milking process. In this process, the milker's hands, clothing, and improper facility operation can cause the pollution of raw milk. The quality of the staff will result in the risk of food traceability. Professional training, appropriate working environment and humane management can reduce the risk of contamination through this process.

3. Transportation and storage. Due to the characteristics of dairy products, these can be easily contaminated and their short shelf life aggravates this condition. For example, a series of chemical and microbial changes can easily occur in the process of storage and transportation. Moreover, if the storage temperature of raw milk is too high or not cooled down in a timely manner, it will cause deterioration of raw milk. It is necessary to monitor in a timely manner the storage and transportation of raw milk. This information is the basis for food traceability. Any error will affect the products' quality. For example, due to the staff negligence led to the loss of recorded data.

4. The procurement testing. Due to the imbalanced distribution of benefits throughout the dairy supply chain, the profit making opportunity of producing

raw milk is limited. This situation can lead some suppliers or famers to sell lower quality milk or to alter milk with different products to cut the costs. In order to maintain the same proportion of protein, fat and other substances, milk suppliers or farmers might add protein powder, whey powder and other additives so that the raw milk still conform to the standards established in the detection process. But this problem leads to increased difficulty in food traceability because advanced testing technologies and instruments are necessary to reduce the risk of alteration.

Processing of primary products and end products

Dairy processing is an important step in determining dairy products safety. In the preliminary processing stages of raw milk and the finishing processing stages of a variety of dairy products, there are many steps that may impact the quality and safety aspect in the dairy processing enterprises. These are for examples, the conditions and status of processing techniques, level of technology, facilities and equipment, the standards of internal quality control, the factory environment, and health status of employees of processing companies. During the process of dairy processing, the company hygiene status needs to comply with the established standards, the quality of equipment and technical management require a certain technological status, the new product formulation design needs to meet the relevant standards, even the packaging materials contamination will impact the quality and safety problem for dairy products. There are three main factors that need to be taken into account when calculating the risk of processing dairy products:

1. Processing. Each process in dairy production must be carefully checked, including operating procedures, the status of equipment operating, testing methods and environment. Real time record of the status of the processing equipment, operating procedures, operating environment, content of pathogenic microorganisms and other indicators in dairy after each processing stage, to control the products' quality. Processed products combine a variety of raw materials and additives; a lot of information to be included in the process of food traceability. If the information is not accurately reported and recorded, food traceability activities may stop here forever. Therefore, strict, systematic and transparent information management systems are keys in ensuring the quality of food traceability.

2. The hygiene of infrastructure. Attention must be paid to the cleaning and disinfection of the pipelines, processing equipment, and other facilities. The degree to which these factors are taken into consideration will affect the quality of dairy products, such as the reproduction of bacteria, reducing protein stability, etc. The records of disinfection and the degree of qualified cleaning of infrastructure can improve the efficiency of product traceability, and strengthen the enterprise management power.

3. Packaging. The management level of packaging equipment and environment directly affect the possibility of secondary pollution of end products in the distribution process. In the packaging process, inadequate sterilization of equipment, substandard filling environment, and improperly sealed packages will all cause dairy microbial contamination. The packaging of the end product recorded a variety of important traceability information. It is the product ID card. Standardized and accurate packaging is therefore the necessary assurance for food traceability.

End products distribution

The perishable and difficult storage attributes of dairy products implies that refrigeration is one of the essential requirement for the distribution of dairy. In addition to ultra high temperature processed (UHT) products and milk powder, dairy products require to be kept refrigerated. Pasteurized milk and its by-products require higher standards of distribution, because even slight negligence will seriously affect the quality. More attention is needed concerning the storage and distribution stages, which are:

1. Storage. A problem of warehouse hardware device, an excess of microorganisms in the environment, or high local temperature will all cause microbial proliferation, and this will affect the product's quality. Food poisoning caused by deterioration and improper management often occurs in the process of food storage. Furthermore, the management efficiency in the process of storage and the degree to which this information is recorded and complete will directly impact food traceability.

2. Transportation. In the process of transportation, dirty transport vehicles, packaging damages, and long transportation time will all impact food quality and might cause safety problem. In addition, the transportation company in order to reduce costs might combine dairy products with different others in the same container, which may lead to contamination. This situation can easily cause food cross-contamination. The uncertainties in the transportation process are one of the important reason affect the quality of food traceability. The understanding of the conditions about the vehicles, personnel, routes, regions, and seasonality is the key to improving food traceability.

Catering trade & Retailing

Food retail is the closest step in the dairy product supply chain and the one in which consumers are more directly involved. This stage can also lead to problem linked to food safety issues. The pluralism and diversity of food sales can lead to many safety risks. The factors that need to be looked at more carefully in the retail stage are:

1. Storage information checking. Verifying the information about dairy procurement, such as manufacturer, date of production, ingredients, etc.

Certified dairy products will be sold in shops. If the information does not match, it is necessary to report it to the management department and deny these products to be sold in shops, in order to crack down on counterfeit goods. The system and comprehensive records of commodity procurement information will assist the food traceability to discover problem products. The complete and accuracy database system can improve the efficiency of food traceability.

2. Retailing. It is the forefront of the food traceability. In the process of selling dairy products to consumers via shopping malls, supermarkets, convenience stores, specialty stores and direct marketing, the status of product operation and management of retailers directly affect the quality of the food traceability. Due to the pressure of competition, retailers may artificially tampered with additives or counterfeit products to cut costs of production or blame other actors in the dairy supply chain as responsible for these other problems. These problems bring many difficulties for food traceability. Strict governmental regulatory mechanism and industry self-regulation system is the basis to exert control on this phenomenon.

3. Catering trade. The retail sector, restaurants, hotels, canteens are the main channels for consumers to obtain the dairy products. The characteristic of this stage involves the activities of re-processing before the food is sold to consumers. Therefore, the requirements about the staff's health conditions and the processing environment at this stage are high. However, hygiene problems are one of the biggest issues in the industry. In addition, the phenomenon of using expired; corrupted and unhealthy food is very high in this industry. These issues are very difficult to be directly linked to a particular stage of the process of food traceability, but it represents a great potential threat. Strengthening the necessary supervision and management steps in the process is necessary to ensure the smooth progress of the activities of food traceability.

Consumer

The stage of dairy consumption is the last part of the dairy supply chain and also involves safety risks. The awareness level of dairy products safety, the ability to use the food traceability information involves risks in the food traceability process. Consumers must be strictly following the prescribed method on the product package to store the products. Pay attention to the environment hygiene conditions, the temperature of refrigeration, the status of product packaging, cross-contamination of food, and the product shelf life. To strengthen the promotion of food safety and food traceability through radio, television, newspapers, websites and other medias, can improve the safety awareness of consumers and also create a better environment for food traceability activities.

In figure 7, the summaries of the identification and analysis of the risk factors in dairy supply chain are shown.

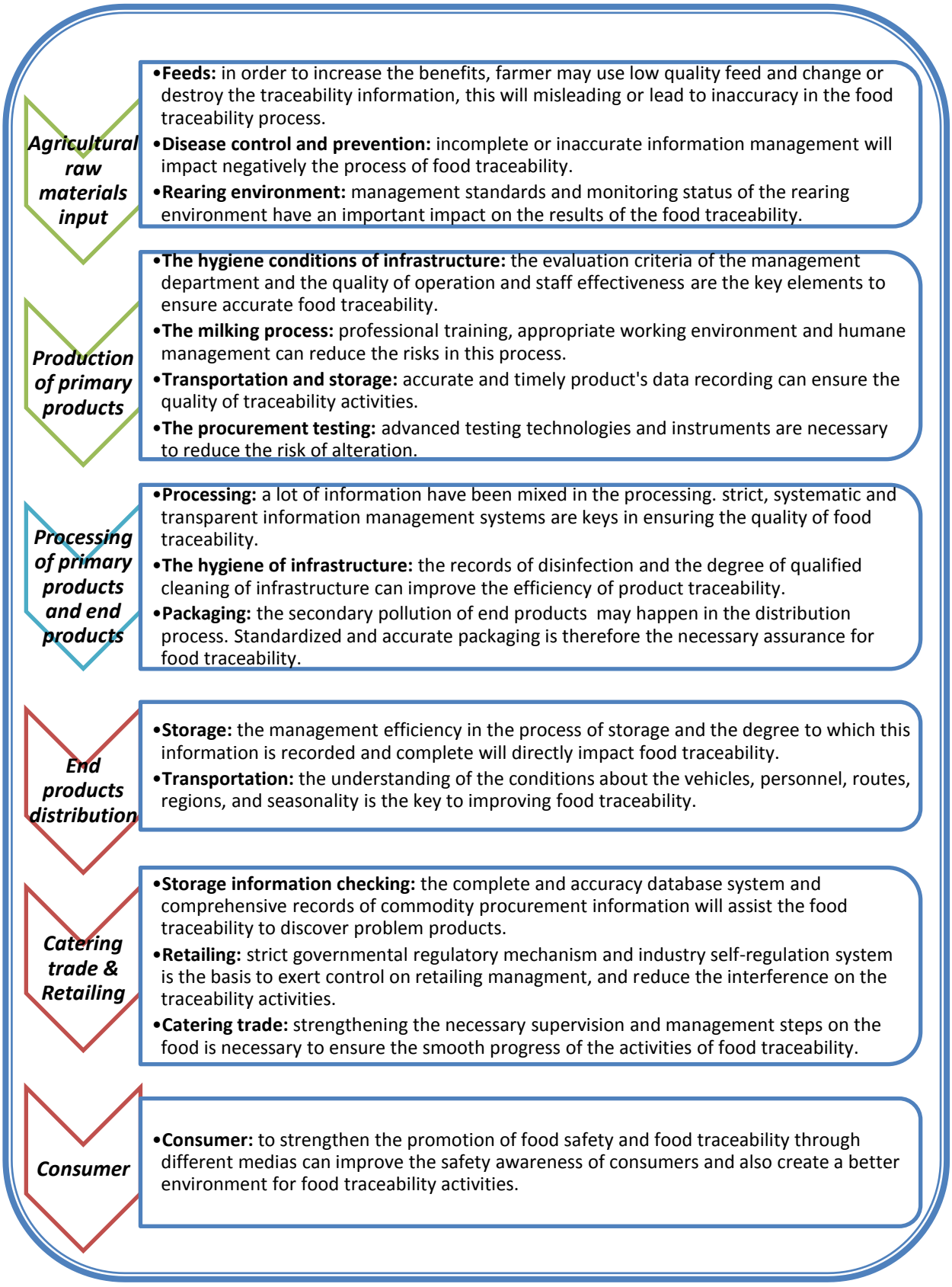

Figure 7 The overview of risk factors impact food traceability in dairy supply chain

4. Discussion, Conclusion and Recommendations

Discussion

According to the research questions, the discussion consists of five aspects.

1. There are three main characteristics to the food supply chain. First, the supply chain is long and complex. It means the food supply chain contains a number of stages, and at each stage, the main actors must deal with many problems. Second, the scale, operation situation and management standards of enterprises are different throughout the chain. It increases the probability of food safety risks and traceability risks. Third, the proportion of logistics outsourcing is large and the consumption cycle is short in the FSC management. The logistics outsourcing increases the length of the food traceability process, and the short consumption cycle increases the difficulty of food traceability activities. These characteristics involve risks and compromises food safety in the supply chain. This three characteristics need to be taken into account when looking at the food traceability process.

2. Traceability is the ability of using the registered marks to trace products history, status of use, location, similar products and activities. The characteristics of traceability include: It covers a wide range of products. The degree and accuracy of food traceability is higher and higher. The traceability technology is improving. The traceability system will become the new standard for the international trade. These characteristics proved the importance of food traceability, and also from this experience arises the need for a higher requirement for the quality of food traceability.

3. The risk factors that affect food safety mainly includes: the food additives problem. The non-food materials problem. The food safety regulations and standards problem. The primary products and agricultural inputs problem. The processing, storing, transporting and environment pollution problem. The application and safety testing system problem. The food safety analysis, assessment and early warning system problem. These problems are concerned by the activities of food traceability. To solve those problems a good quality of food traceability is very important.

4. The risk factors that affect food traceability can be divided into two main aspects, technical risk factors and managerial risk factors. The technical risk factors are the factors that occur due to applying and innovating food traceability technology. The managerial risk factors are focus on the existing and potential human-centered risk factors. During the process of food traceability, they are located in the various parts of the FSC. This research mainly paid attention to analysing the managerial risk factors in the FSC.

These managerial risk factors contain three parts: in the planting and breeding part, the risks in the process of agricultural raw materials input and production of primary products are the main problems to influence the quality of food traceability. The uneven distribution of profits is the main cause of these risks. In order to increase their own benefits, some farmer may use inferior feed and tampering the traceability information. In the processing part, the key to ensuring the quality of food traceability is the management quality of processing enterprises. But the poor collaboration and the low transparency affected the management quality. In the distribution part, the situations of storage and transportation, and the management of the sales places have an important impact on the quality of the food traceability. The differences in laws, regulations and management systems in different countries will increase the risk of food traceability. When these risk factors exist in the food supply chain, they will cause all kinds of damages, efficiently avoiding and reducing these risks will better guarantee the quality of the food traceability.

5. This research takes dairy supply chain as an example of the complex system behind food traceability. The dairy supply chain comprises a vertical extension, which involves the primary industry (agriculture and animal husbandry), secondary industry (food processing industry) and tertiary industry (distribution, logistics, etc.). Any stage of the dairy supply chain can imply a potential food safety issue. The dairy market is very broad, so the requirements for the quality of the food traceability are also high.

   According to the identification and analysis of the risk factors in the dairy supply chain, the research further confirms the main managerial risk factors that affect the quality of food traceability, and also the reasons and the negative effects for these risks. It provides a reference to strengthen the management of food traceability activities. However, the study of dairy supply chains can only be achieved by analyzing current literature and reports. Therefore one of the limitations of this assignment was that without field research and expert interview, the information available is not comprehensive enough. For example, enterprises in order to solve practical problems need to adjust these basic principles to their own situation.

Conclusion

Traceability system is an information system. It helps achieving product traceability by correctly identifying, accurately recording and effectively communicating product information. It was developed as a solution following the food safety crisis, consumers demanding for food safety standards. It is the result of the study of market behaviors among enterprises and government regulation of food safety (Dong et al. 2011). There exists a wide variety of food traceability technology, such as EAN • UCC system, barcode technology, RFID, GPS, GIS. Traceability system records the history of food in the supply chain. In this way, food traceability can

assist enterprises to effectively monitor the internal process of food production and accurately identify the source of the problem. In the entire supply chain, with the principle of “one step forward, one step back” it can help identify who are the enterprises responsible at each stage in the chain, and provide sufficient information for them to protect their own benefits when incident occurred.

Many food industry firms comply with the “one step forward, one step back” process, which means that each actor involved in the food supply chain needs to be able to accurately trace back its products or ingredients one step back and one step forward. This process allows them to be able to be competitive on the market, because of export requirements, private standards, or internal food safety practices. In this way it lessens the financial risks companies must take (European Commission 2007). Traceability systems can also strengthen the strategic partnership among each enterprise, increase customer satisfaction and improve the competitive advantage of the entire supply chain. Food traceability is also beneficial for companies in the agro-industry as it allows them to ensure of the quality of their product, which is essential in a fiercely competitive market. In the same manner, food traceability ensures public trust but to be effective, all actors in the chain must comply and link together in order for the whole chain to be covered.

The objective of this thesis is to enhance the companies’ ability of food traceability by analyzing and understanding the risk factors that affect food traceability. In order to achieve this goal, a wide range of literature was studied and a case study of one specific industry was analyzed. The research discovered three main managerial risk factors that affect food traceability.

Firstly, there is a difference in return on investment and profits distribution problem. Producers and proprietors in order to ensure their own interests, may intentionally alter or change food traceability information, this can cause a serious impact on the quality and accuracy of food traceability.

Secondly, the poor collaboration and the low transparency in the food supply chain is also a factor that affects food traceability. Normally, enterprises are self-interested and more concerned with their own business’ profits, rather than the interests of the entire supply chain. Because of economic downturns and increased competition pressures, the trust and transparency between enterprises is bad. This has brought a lot of obstacles to food traceability activities.

Thirdly, it is improvement of the regulatory system, the intensity of supervision, and the degree of the industry self-regulation are key aspects. In the complex food supply chain, especially the international supply chain. The difference between countries and regions in laws and regulations and the maturity level of industry lead to increasing quality gaps in food traceability activities.

Recommendations

In order to enhance the accuracy and consistency of food traceability, this study proposed following recommendations concerning the different problems:

- For the first problem. In the dairy supply chain, the capital investment in production sectors accounted for 75% of the whole industry chain, the processing sectors accounted for 15%, and the distribution sectors accounted for 10%. However, the proportion of profits distribution for these three sectors is 1: 3.5: 5.5 (Su 2010). This situation brings a huge potential risk in the entire supply chain. Due to this unequal distribution of profits, many are tempted to alter the production and sell counterfeits products, which can have a serious impact on the quality of food traceability (Gao 2009). The way to solve this problem is to improve the distribution mechanism of revenues, and enhancement of the internal stability of the supply chain. Monopolies of individual companies in one particular stage of the supply chain should be prevented, to ensure that the benefits in each stage will be controlled and distributed more equally. The industry associations and government regulators need to play an active role in this issue.

- For the second problem. Due to the impact of the financial crisis, economic downturns, and political upheaval, the operation and management of the enterprise is more conservative and self-protection awareness is stronger. The excessive sense of crisis and the pressures of competition affected the overall interests of the supply chain (Zheng 2008). Food traceability needs to be carried out in the entire supply chain. Low transparency management and unfavorable collaboration relationship greatly reduced the efficiency of food traceability. The way to solve this problem is to strengthen the collaboration in the different links of the supply chain, and gradually establish a profit and risk sharing chain alliance should be stimulated. Key parts in achieving this would be strengthening communication, sharing supply chain information, avoiding confrontation and seeking common ground and resolving differences along the supply chain. For example, this can be achieved through contractual agreements, informal cooperation (includes exchange visits, short-term exchange of employees etc.), joint ventures, equity participation, and international cooperation. In order to build and maintain a long term and close enterprises collaboration.

- For the third problem. Due to the impact of economic globalization, the scale and complexity of the food supply chain is also increasing. Enterprises and products in a supply chain may come from anywhere of the world. The differences between countries, regions and industries, especially in the development of laws and regulations, the functioning of the regulatory department, and the standards of the industry self-regulation will increase the risk of food traceability.

The way to solve this problem is to increase legislative speed, setting up international food safety laws and regulatory system mainly aimed at covering all stages of food production, from processing to distribution all the way to consumption. Food regulatory departments should be centralized to ensure this system could efficiently operate. Meanwhile, governments need to strengthen the day-to-day supervision for the food industry, improve the methods of management, and develop a management system based on laws to increase the intensity of penalties for violations. State authorities also need to encourage enterprises to comply with the laws on this subject, and improving the responsibility awareness of food safety. Food regulatory departments should encourage the reform of the existing industry associations to truly become non-governmental public organizations because it would play a role in decreasing risk factors. Food regulatory departments should play the role of industry self-regulators, and become a bridge between companies and government, to assist the government in establishing and maintaining market order.

In addition, the moral level of the supply chain participants is also very important. Whether the employees work attitude is rigorous enough, the business is focused on integrity, and the development of the industry is constructive are all keys factors that come into play.

Finally, there are also some recommendations for the relevant researches in the future. These assignments only focuses on the managerial risk factors, it does not take into account the technical risk factors. It is also important to take into account the factors that affect the quality of traceability. Thus, further study should look at adding more factors to satisfy the different requirements. Furthermore, this study takes dairy supply chain as the example, but the characteristics of the dairy chain will be different with the other food supply chain, such as wheat or fruit supply chain. So the adaptation range of the research is not wide enough. Therefore, a multiple food supply chain analysis would be useful for further study and it could help obtain a more convincing result.

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Appendix

The Food Traceability System