

An Integrate RFID Traceability System for the Halal Supply Chain

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Abstract

With the rapid growth of the global Halal market, a large number of standardization and certification organizations have been established worldwide. This paper summarizes key issues of Halal such as definition, Halal standard and Halal certification firstly, and then analyzed and interpreted the Halal supply chain. Further, this study proposed an integrate RFID Halal meat traceability system for entire Halal supply chain on the basis of the introduction of RFID technology. The benefit of this research can trace and track the Halal meat products, and help consumers to choose and buy the safety Halal products by using the traceability system to get the complete Halal information.

Keywords: *Halal Supply Chain, RFID Technology, Traceability System*

1. Introduction

Halal food products are the main and most recognized components of the Halal industry. The Halal food market is worth 16% of the entire global food industry in currently. Asia, Africa and Europe account for respectively 63%, 24%, and 10% of the global market [1]. According to the estimation from [2], the total number of Muslims worldwide occupied at 1.62 billion heads, representing 23.4% of an estimated 2010 world population of 6.9 billion. Meanwhile, China as a non-Muslims country has a Muslim population of approximately 20 million according to the fifth population census. Therefore, the Muslim population constitutes a considerable market segment in today's Halal food market. Nowadays, the global Halal food industry is developing. Currently, China food industry also invests in the production of Halal food; even some Chinese manufacturers export the Halal products to Muslim countries. However, most of Chinese manufactures are not accepted and recognized by oversea Muslim consumers due to their products without international mutual recognition of Halal certification.

The Ningxia Hui Autonomous Region is the unique district where government support local food manufactures to develop Halal beef & mutton industry, and it already established the local rules of Halal certificate which accepted and recognized by the Chinese national certification and accreditation supervision and management committee. On the other hand, the state council has officially approved build inland open economy test area in Ningxia, at the same time set up a comprehensive free trade zone in Yinchuan city on September 10, 2012. Under the Yinchuan comprehensive free trade zone, Ningxia Halal food certification center for international trade can carry out the work of Halal food certification. Presently, Ningxia Halal food certification center for international trade has reached a mutual recognition agreement with Malaysia which is seen as the world's most

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successful example where a single Halal standard is applied throughout the some related Halal certification training, and it has been carried out with the help of Malaysia. At the same time, Ningxia Halal food certification center for international trade is actively consult with the Saudi Arabia, Egypt and other Muslim countries to negotiate for Halal food mutual recognition agreement, efforts to expand overseas markets for Ningxia Halal food, continuously improve quality, reputation and recognition in Muslim countries and market share.

On the one hand Ningxia local government layout has occupied a high level, and local enterprises also want to develop the Halal food industry and Halal brand. On the other hand, Halal beef and mutton industries as one of the advantage of priority to the development of characteristic industry in the local national economy obtained efficient support from both government and enterprises. Therefore, how to obtain mutual recognition from local and oversea Halal market and maintain Halal status and quality traceability of Halal product becomes a key problem.

2. Key Issues of Halal

2.1. Definition of Halal

Halal is defined in the holy Quran and the Sunnah actions, sayings and tacit approval and is a dietary obligation for Muslims. Islam teaches Muslims to consume Halal, the prohibition of haram and avoid doubtful things [3]. In accordance with the [4], Halal is an Arabic word meaning lawful or permitted, the opposite of Halal is haram which means unlawful or prohibited. Halal is a Quranic term that applies to all facets of life such as behavior, speech, dress, and dietary laws etc. Nevertheless, the term is most commonly used in the narrower context of just Muslim dietary laws in non-Arabic-speaking countries, especially where meat and poultry are concerned. Halal is not static, but goes through evolution from a Muslim company, Halal product, Halal supply chain, to a Halal value chain [5]. But here this term will be used only in relation to food products, meat products, food ingredients, and food contact materials. All foods in Islam are considered Halal except the following:

- ◆ swine/pork and its by-products;
- ◆ animals improperly slaughtered or dead before slaughtering;
- ◆ alcoholic drinks and intoxicants;
- ◆ carnivorous animals, birds of prey and certain other animals;
- ◆ foods contaminated with any of the above products.

Based on 'General Guidelines for Use of the Term Halal'(CAC/GL 24-1997 1) issued by the Secretariat of the Joint FAO/WHO Food Standard Programme (2007), Halal food is defined as food permitted under the Islamic Law and should fulfill following conditions[6]:

- ◆ does not consist of or contain anything which is considered to be unlawful according to Islamic Law;
- ◆ has not been prepared, processed, transported or stored using any appliance or facility that was not free from anything unlawful according to Islamic Law;
- ◆ has not in the course of preparation, processing, transportation or storage been in direct contact with any food that fails to satisfy (1) and (2) above.

2.2. Halal Standards

There is increasing demand for Halal products globally, but Halal industry is still lacking in standardized Halal standards, therefore, resulting in a slow industrial growth presently [7]. For this issue, there are two reasons that one side is every Muslim countries have their own standards and guidelines, another side is some countries have various Halal authorities or agencies. Both sides are providing multiple Halal standards and would

cause questionable Halal certifications. Hence, it is difficult to formulate a global Halal standard for the Halal industry to implement worldwide because of above mentioned two reasons according to [8]. To have a common recognized Halal standard will be difficult for different local Halal players, because they have been operating on their country's own standards previously.

Under global standards level, the largest institution is the World Halal Council (WHC) which oversees 41 Halal certification agencies from various countries, and it is established in Thailand [4]. WHC is establishing a unified Halal food standard worldwide. The Organization for Islamic Conference (OIC) is a resident office of the United Nations; the secretariat is located in the city of Jeddah from Saudi Arabia. It also developed general guidelines which named as ICRIC-MHS-0110 on Halal food for its 57 member states. The Global Halal Management System (GHMS) is based on the Thai Halal standard THS24000: 2552 developed by the Central Islamic Committee of Thailand (CICOT). GHMS covers five major aspects: Halal Fundamental Requirements, Quality Management Systems, Food Safety Assurance Plans, Corporate Social Responsibility and Environmental Management and Sustainability [9].

Under the international collaboration level, some collaboration organizations have involved in building mutual recognized Halal standards which fulfill within their member states. For examples, the Association of South East Asian Nations (ASEAN) established the ASEAN general guidelines on the preparation and handling of Halal food to be applied in 10 South East Asian countries; the Gulf Cooperation Council Standardization Organization established the GSO993/1998 and GSO1931/2009 to govern conditions for animal slaughter according to the rules of Islamic law, which is applied in 7 Persian Gulf countries.

Under standards on country level, besides the Thai Halal standard THS24000: 2552 mentioned in the previous section, other countries from Asian have also set some Halal standards. Malaysia has set some international quality standards and the Malaysian standard MS1500:2004 to be complied with Malaysian food manufacturers [10-11], MS1500:2004 was certificated by JAKIM which has developed a traceability system, through this system details of Halal products can be verified by consumers [12-13]. Indonesia has also set general guidelines of a Halal assurance system to ensure that the entire production process complies with Islamic laws. It is conducted by LPPOM MUI (The Assessment Institute for Foods, Drugs, and Cosmetics, Indonesian Council of Ulama). The Austrian Standards Institute (ASI) has published its national Halal standard ONR14200:2009 to define Halal food chain requirements for compliance of foodstuffs to Islamic law. United Arab Emirates has set the UAE993:2000 which is a standard concerning animal slaughtering requirement according to Islamic law in the UAE.

2.3. Halal Certification

The concept of Halal is an absolute key to consumption for all Muslims around the world. But nowadays Muslim consumers are confused from the selection of Halal products. Therefore, manufacturers have been forced to use Halal certification and logo to inform their target consumers that their products are Halal. In another words, Halal-certified product is the main reason behind Muslim consumers purchase Halal products for everyday consumption. In general, Muslim consumers look for the authentic Halal certification issued by the government agency due to the Halal certification carries high reputation in eyes of Muslim world. Furthermore, Halal certification such as Halal logo or certificate of compliance issued by reputable and licensed agency, shows that the product have sufficiently met Islamic dietary according to [14-15]. And then the Muslims will be reassured without any hesitation and doubt when the Halal logo or certificates is labeled on a product.

Except acted on the recognition of Halal food, Halal certification is also applied for the dining outlet and restaurants when Muslims will look for places to eat. It shows that Halal

certification also applies to food service provider as well. With the expansion of the service scope of Halal certification, [15] mentioned that it must be authorized and issued by a trustworthy government agencies or Islamic organization for the purpose of prevent from any fraud, fake and misleading certificates. Finally, in order to achieve standardized Halal certification, market need, consumer demand and industry development must be reengineered and realigned according to [16], and the procedures for Halal certification mustn't to be too strict or too lenient. Generally, the Halal certification process is divided into five steps which are (1) Application/Document Approval, (2) Premise Inspection, (3) Panel Committee/Appeal Committee, (4) Issuance of Halal Certification and (5) Monitoring and Enforcement.

2.4. Halal Meat Supply Chain (HMSC)

According to Halal Industry Development Corporation (HDC), Halal supply chains include everything from the procurement and preparation of genuine Halal ingredients to the manufacturing and delivery of the final product all the way to customer shelves. The Halal meat supply chain is such kind of process which must be Halal from the beginning of the supplier to the end consumer. The whole process starts from suppliers, through farming, slaughtering, processing, storage, transportation, distribution and display to the consumers (see in the Figure 1). However, the concept of HMSC is still confusing the industry players, and it was result in some misunderstanding due to some vulnerabilities of HMSC. These vulnerabilities are derived from the credence quality attributes, such as importance of maintaining Halal integrity throughout the supply chain [17-18], essence of avoiding doubt in Halal food [19], lack of control of Halal food norms [20-24] and sensitivity of the Muslim consumer towards Halal [25]. The key issue from those vulnerabilities is how to maintain Halal integrity and avoid the haram contamination of HMSC. On the other hand, haram contamination can also occur in the HMSC, e.g. from breeder to livestock farmer, distributor, slaughterhouse, meat processor, retailer, and consumer [26-28].

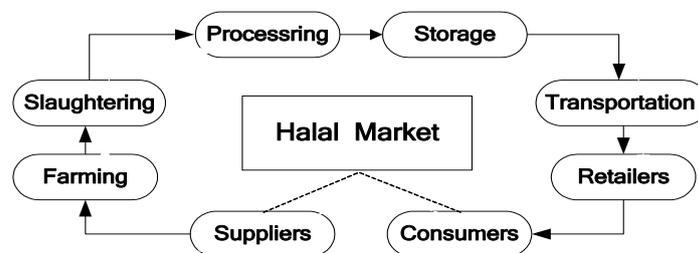


Figure 1. Halal Meat Supply Chain (Source: Adapted from [29])

Here gives a very brief interpretation for the Figure 1. In the farm, raising animals should be in line with of Sharia law and all meats must be from Halal animals. After the success of farming, slaughter is a very important practice in process of Halal food. The slaughtering must be practiced by a Muslim and the knife and/or tools used in slaughtering should be very sharp. Storage and transportation of Halal food should again be complied with Halal requirements. Halal food should be separated from non-Halal food to ensuring there is no direct contact between them. In shops or outlets, Halal food should be labeled in order to distinguish them from others for Muslim consumers. It is important for the displayed Halal food to be separated from others and avoid any possibilities to touch each other directly or indirectly.

3. Using RFID Technology for Halal Traceability

3.1. RFID System

In the food industry, RFID (Radio Frequency Identification) systems could be exploited for traceability, logistics as well as for anti-counterfeit purposes. RFID is a contactless/wireless automatic identification technology. It uses radio frequency signals to implement a contactless/wireless communication between RFID reader and tags so as to automatically identify the targets and obtain data. Currently RFID technology has been used in a diversity of applications such as animal ID, transportation payment, access and security, asset management and retail sales, product tracking, inventory systems and so on.

In general, a complete RFID system is made up of tags, RFID reader, data exchange and host system loaded with the necessary software. The RFID tags play the role of information carriers, and each tag has a unique electronic series code embedded in it. Basically, there are three types of RFID tags which are passive RFID tags, active RFID tags and semi-active RFID tags. The major difference among these types lies in the power supply of their tags. The RFID readers which composed of RF antenna, transceiver, MCU and peripherals, is used to read the information in tags, and then send it to host systems if the identity of a tag is approved. RFID Readers come in different shapes and sizes and work at different frequencies, the higher the range of frequency the higher the read range. However, the size of the tag's antenna determines the ability to read the signal at certain distances. Finally, the host system is responsible for processing the received information.

3.2. Halal Traceability

At present, Halal consumers need more information of products that they wanted to purchase due to the Halal awareness. They want to know detailed information related to the activities that happen along the Halal supply chain. To satisfaction of their customers' demand, Halal traceability should be applied in supply chain.

Halal traceability can record all information in Halal supply chain, include all kinds of information from different stage of farming, slaughtering, processing and retailing. To make Halal traceability system work effectively and efficiently, every role in Halal supply chain must record every producing data and mark on package. And the critical Halal control points (HCPs) can be fully monitored by having a Halal traceability system in order to maintain Halal status of products in Halal supply chain. Therefore the comprehensive and reliable traceability system can increase the Halal transparency and strengthen the Halal integrity in the Halal supply chain. And then the traceability system can also avoid cross contamination between Halal and non-Halal elements. In general, from the Halal food industry perspective, Halal traceability can be used to trace the Halal status of a particular product at every stage of the supply chain. For example, when the suspected product is cross contaminated with non-Halal elements, through the traceability can easily identify the cross contamination point and further action can be taken later. In consumers view, Halal consumers also can access the traceability web site and query producing traceability information after they purchased products.

In the view of existing tools to trace the Halal status, different researchers have different point, for examples, [30] considered that it was unreliable, [21] mentioned that it was lack of security, [31] agreed that it was not real time basis and [32] indicated that it need to take longer time to race. Fortunately, existing technology such as RFID, barcode and internet can be used and manipulated to develop a reliable tool for Halal traceability.

3.3. An Integrate RFID Halal Traceability System for HMSC

3.3.1. An Integrate RFID Halal Meat Supply Chain: After combine RFID technology, the Halal traceability system can cover entire supply chain. In order to comply with critical Halal control point, RFID technology need to be imply and apply at every stage in the HMSC to sustain the Halal integrity of the product itself and to suit the Halal consumer requirement. Information which read and stored by the RFID system could be used to serve the traceability system. Therefore this paper try to give a detailed interpretation for an integrate RFID Halal meat supply chain (see the middle column of Figure 2).

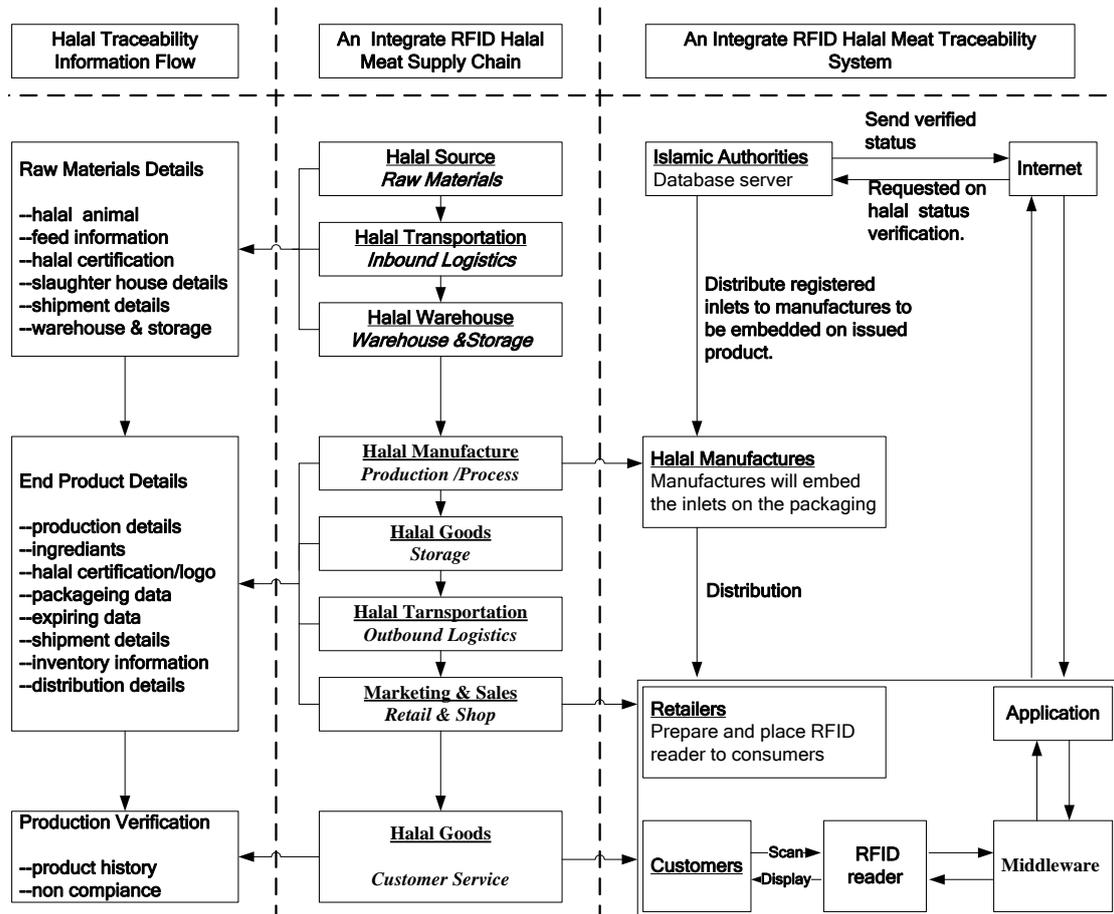


Figure 2. An Integrate RFID Halal Traceability System for HMSC (Source: Adapted from [23] and [29])

During the preprocessing stage, it is include in raw materials, inbound logistics and warehouse & storage sub-stages, RFID tags are used to record those basic information. *i.e.*, in raw materials sub-stage, let livestock have a RFID tags, so that we can identify livestock by RFID tags and record their basic information such as their weight, grow status etc. Livestock being feed with good, clean, permitted and legal nutritious food, and this breed information also be recorded, even need to record the medical treatment information when livestock is sick. When livestock go to the slaughter step, the slaughter house detailed information should be recorded by RFID equipment too. In the inbound logistics sub-stage, RFID system used to be monitoring the flow of inbound vehicle, include in trucks and containers. In the warehouse & storage sub-stage, RFID system used to be monitor Halal meat from mixed with non-Halal product.

During the processing stage, a quarantine station will check Halal meat which prepares to produce or process is OK, and then the quarantined information also need to record. If those prepared Halal meat have problem, we can use RFID to identify problem livestock.

After quarantine, the prepared Halal meat will be used to process or produce to become finished and semi-finished products which need to repackage by production house. This processing information is also recorded by RFID system for future trace and track.

During the post processing stage, it is include in storage, outbound logistics, retail and customer service sub-stages. In the storage sub-stage, RFID system used to be monitoring the finished products and semi-finished products from mixed up with non-Halal product. In the outbound logistics sub-stage, RFID system used to be monitoring the flow of outbound vehicle, include in trucks and containers. It also need to do segregation in the container if there is non-Halal and Halal product together in the same container. Even the distribution information need to record by the RFID tags. In retail sub-stage, it must use RFID reader and temperature measure equipment in transport to record too high temperature or other situation, if products have preserving requirement. And it also need to maintain the freshness, cleanliness and product safety to be sold. During consumer purchasing Halal products, consumers can take the product to RFID reader which provide by retailers to understand the food traceability information of the product that they want to buy. The purpose of customer service sub-stage is mainly to improve service quality and look up for any complaint from customer.

3.3.2. An Integrate RFID Halal Meat Traceability System: There are four entities involved in this traceability system such as Islamic authorities, Halal meat manufactures, retailers and consumers (see the right column of Figure 2). A massive number of Halal meat products involves in this study, therefore, passive tags are selected to store product information due to its lower cost. RFID manufactures registered the unique identification number for all tags which are distributed to the Halal meat manufacturers to be embedded on issue products. Those unique identification numbers are mapped to corresponding product information in Halal database of Islamic authority. The database server stores Halal products information and RFID inlet unique identification number accordingly. And then the Halal meat manufactures embedded RFID tags on the package of their products before they send finished products to retailers. In the retail store, the retailers place their products and RFID readers on the racks for their customers to verify product information.

To trace and track finished product is most important function of Halal meat traceability system. Before buying products, the consumers will validate product status so that they place products with embedded tags inside the frequency range or place products in front of RFID reader directly, then the reader will read the tags and upload related data to middleware which acts as a connection layer to manage and process the flow of data coming from readers. After that the middleware send the flow of data to the application layer and request on Halal status verification through internet from Islamic authorities. The system will look up the requested identification number in the database and perform regular checks. Finally the system will output the verified information of Halal meat traceability back to the customers. This information can help consumers to confirm the Halal status and help them to buy those products. In addition, Halal traceability information flow such as raw materials information, end product information and product verification information etc show in the left column of Figure 2.

4. Conclusions

With the increase of demand for Halal meat products, factors such as Halal standard, Halal certification and Halal traceability must be given more attention to satisfy Halal consumers. Therefore, this study discussed and analyzed issues of Halal, HMSC and using RFID technology for Halal traceability respectively. This research object of the study is to realize the traceability of Halal status and quality of Halal meat product. Therefore, the combine RFID Halal meat traceability system can help consumer to get complete information about Halal meat products and purchase safety. This system can

record production information more automatically through the supply chain. And it can complete record every Halal status and Halal data of product. For the purpose of testing the relationship between factors that have been stated in this study, the empirical study should carry out in future research.

Ningxia local governments and enterprises have been formed consensus to develop the Halal meat industry and Halal meat brand because of the Halal beef and mutton industry already has become one of the most potential competitive advantage industries. Base on this requirement, it is imperative to research and develop a set of Halal meat quality traceability system. And the conclusion of this study could be demonstrated to beneficial for local Halal enterprises that to guarantee the products match the requirement of Halal, to strengthen the confidence of Halal consumers, to support for shaping a nice Halal brand image and to enhance competitive ability in domestic and oversea Halal market.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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