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Implementation of traceability in food industry with special allusion to meat industry

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Abstract
Traceability is progressively becoming standard across food industry. This is resulting in emergence of various traceability concepts suited to different industry needs. Outbreak of livestock diseases and their transfer to humans have generated requirement for reliable traceability in meat industry. This traceability would track an individual meat product back to its animal of origin. International Organization for Standardization have defined traceability as ability to follow movement of food through specified stages of production, processing and distribution. Traceability systems are record keeping systems that show the path of particular product from suppliers to consumers. Traceability systems apart from identification provide other information like country of origin, species. Traceability systems range from paper based systems to bar codes, radio frequency identification devices. Tracing of animals provides confidence in certification schemes and it forms an essential component of risk management strategy as well as is a key requirement for post marketing surveillance.

Keywords: Traceability, barcodes, tracking, radio frequency identification devices

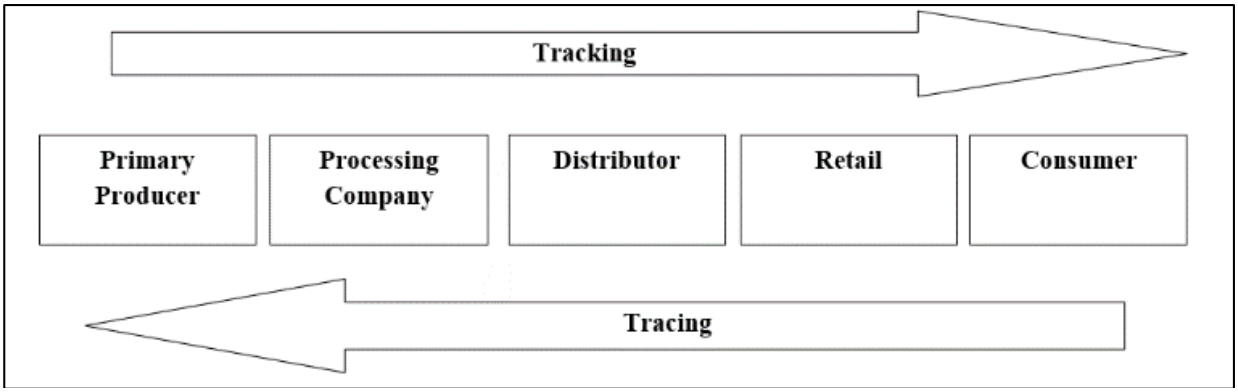
Introduction
With the rapid increase in global trade and communications, the need has been created for the identification and establishment of product traceability system that can be used in all industry sectors. Traceability is being widely demanded in the food industry due to rise in food crises and need of transparency in food chain. Traceability in the food industry aims to create a link between the various steps in the entire food chain i.e "from farm to fork". These steps include animal production at the farm, processing in meat plants, distribution to wholesalers and retailers and right through to the moment the food is placed on the consumer's table [1]. A greater confidence in certification schemes like their disease-free status can be established by means of well developed traceability system [2]. Traceability is a prerequisite for post-marketing surveillance and a vital part of any risk management strategy.

A product can be identified and tracked to its point of origin via traceability. Product traceability is very important to reliability. Product traceability is the process of maintenance of records of all materials from purchase to finished goods where a unique number identify a part, batch or a finished product. If a particular lot of a critical component is found to be defective after being used in product that is already sold, traceability provides a means of identifying the units for recall. The meat products require complete traceability [3].

Traceability as defined by the International Organization for Standardization is the ability to follow the movement of a food through specified stages of production, processing and distribution. According to ISO 9000 (2005) [4] standards, traceability is the ability to trace the history, application or location of that which is under consideration. ISO 22005:2007 [5] describes the principles and requirements for the design and implementation of a food traceability system. By the means of this standard various organizations operating at any step of the food chain can trace the flow of materials such as food, their ingredients and packaging, identify necessary documentation and tracking for each stage of production, ensure adequate coordination between the different actors involved, improve communication among the involved parties, improve the appropriate use and reliability of information, effectiveness and productivity of the organization.

The terms tracing and tracking are commonly used in the traceability. [6] defines tracing as backward process where origin is identified by records or history in supply chain and tracking is the forward process where end users and trading partners are identified by location in supply chain [7].

Tracing is used to verify the certainty of proclaimed characteristics such as organic status of the product, specific origin, appellations and fair trade. It is also used in case of withdrawals or recalls of products. Tracking and tracing system must be linked with physical transportation and information system [8]. The figure 1 illustrates tracking and tracing along food chain [9].



The figure 1 illustrates tracking and tracing along food chain

History of Traceability

Traceability is an emerging concept but the roots of tracing live animals and animal products has been very old. Various cue illustrate that livestock farmers, those in charge of animal health and production were concerned with traceability from a very early stage. Individual identification of live animals by means of body markings has been practised for over 3,800 years. Branding with a red-hot iron, with or without a written record was employed on valuable animals such as horses in most ancient civilizations. Although modern traceability techniques were not available in the 17th Century, our ancestors practised indelible branding and strict health certification. Animal products were monitored and it was mandatory that these products could be traded internationally only when accompanied by a certificate of origin guaranteeing safety [10].

Meat Traceability

McKean (2001) [11] has defined traceability of meat as the ability to maintain a reliable custody of description for animals or animal products through various steps within the food chain from the farm to the retailer. Traceability systems are record keeping systems that show the path of a particular product from suppliers through intermediate steps to consumers. Apart from identifying the product, traceability systems describe other information such as country of origin, species and best by date that is associated with the product. Traceability systems include paper-based systems, bar coding and radio frequency identification devices (RFID).

Meat processing industry have formulated the tracking system that is capable of identifying products origin by means of ear-tags. The relevant information such as breed, category, grade and ear tags are transferred to the carcass at slaughter. The animal tracking from slaughter onwards becomes increasingly difficult. Conventional traceability can be achieved by manual or computer assisted paper-based tracking systems. These systems are based on the processor that assignes each animal with a unique sequential production number which corresponds to the animal's passport. This information is used in the proposed tracking system to transfer the data using combined radio frequency identification device and barcode readers from the carcass to the traceability database and linking them to the plant's material handling system (MHS) [12]. Automated material handling and RFID based tracking systems include flatbed conveyors [13]. MHS that are based on flatbed conveyor systems control complexities and extra storage equipment such as trays and additional manual activities.

Automatic handling and routing large numbers of individual prime cuts to processing stations can be achieved by means of overhead conveyor system. This system renders several benefits that includes utilisation of space and improved plant layout design, natural segmentation of meat cuts, maintenance of traceability, cheaper solution to complex routings using junctions, minimal effort from operators in handling material, ease of interaction with software systems and flexibility for different processing configurations. Primal cuts are transferred by means of carriers/trays along the designated track to the working stations where the operators receive the product for further processing. The trays are diverted and fixed using mechanical and electrical means to the working area of each station and thus act as a workbench for the designated prime cut. The carriers are designed to hold a microcircuit card (read/write RF smart label) with the unique code corresponding to animal information. This code remains with the tray, the prime cut and its associated trim/fat through the process until the meat is evacuated from the tray and transferred to the corresponding packs [12]. A unique identity of each prime cut is established that can be accessed along the system. This code can be related to the corresponding carcass that holds a fully traceable passport to the farm of birth. Generated codes in order to ensure the integrity of the system can be finally translated into commercial codes that are used by retailers such as URWIS (Uniform Retail Identity Standards).

Tracing systems

Tracking system main objective is to minimise the effort to seize timely and accurate information on the movement of material by means of best suited technology. There are some established tracing and tracking technologies that have been introduced to the meat industry by researchers and practitioners. These technologies include the following:

- Bar codes: Its components include scanning device, a portable terminal and a label [14].
- Microcircuit cards: These cards can store information on the items being moved along the system by being attached to the item or the conveyor.

- Radio frequency tags and transponders (RFTT): The most common utilisation of non-contact RFTT microcircuit technology is tracking the movement and location of containers as they move through the network to the ultimate recipient [14].
- Radio frequency tags: Automatic identification and movements of control assembly line operations can be tracked via radio frequency tags. The main advantages of these tags are that they eliminate key entry, permit wireless operations and reduce human error.
- Biocoding: Individual batches of products can be identified with the use of this technology.
- Chemical markers: These can be added in minute concentrations (parts per billion or parts per million) to products like stamps or tattoos in order to maintain and retrieve information during the process [15].

Characteristics of Traceability Systems

In the recent years there has been tremendous rise in no. of traceability systems/concepts as its merits are being clearly realised by the people. These concepts and systems have been boosted by both private and public sectors and have addressed several needs. Product identification, product tracking, maintenance of information relating to the product and its movement are the basic characteristics of traceability systems. An important feature of a traceability system is the ability to identify that which is to be traced. Ideally the product identifier should identify the unit or batch, be secure, be permanent, retain identity throughout the product life-cycle, be simple to read and capture identifying data and not hinder its host [16]. Many methods are being used for tracing that are applicable in the meat industry. These methods have been illustrated in table 1

Table 1: Examples of Some Tracing Methods [17].

1.	Live Animal	Visual Ear Tags RFID Ear Tags Bar code Ear Tags Tattoos Antibodies by injection
2.	Slaughtering and processing	Paper Bar Codes RFID Tags Batch Markers Molecular Bar Codes Quantum dots Microwave radar
3.	Retail and Distribution	Machine Readable Codes
4.	Consumer	Numerical Codes Public Access Website

DNA as a traceability tool

An effective and trustworthy traceability system is essential for the assurance of food safety and quality. Food fraud is not completely prevented by the various traditional traceability systems that only rely on the recording methods. Traceability systems involves devices that are attached to an animal or a piece of meat. A seamless connectivity within the entire food supply chain can be facilitated by DNA-based traceability techniques. DNA is a useful tool for proof of identity and audit in meat traceability systems as it is unique to an individual [18]. The basic principle underlying DNA based traceability is that every animal is genetically unique and that the animals own DNA code can be used to identify it and products derived from it [1]. The various merits of this system are that the code is permanent, unique to the individual and remains intact throughout the life of the animal or product. As a consequence there is no need to establish an external product labeling system.

DNA extracted from any point along the production chain can be equated with the history of the animal, thus providing the foundation for an individual animal traceability system [3]. DNA tracking can associate meat back to the farm of origin, bypassing the costly step of tracking through the plant. DNA can be detected in cooked as well as fresh products.

Apart from its utilisation in meat traceability, DNA can be used for brand protection [19], fraud detection [20] and detecting contamination with pathogens [21]. Meat processing systems can be forward audited by tracking individuals and their components, during the progress through the plant. However, DNA is the only way to unequivocally reverse audit a meat production plant.

DNA Sampling

Identity of the individual cannot be made by simply extracting a DNA sample from a piece of meat or any biological product, though its possible to deduce some of the characteristics of the individual. The identity of individual can only be established by comparison with reference sample. Thus, DNA-based traceability system requires that reference samples are available from any animal for which traceability might be required. Reference samples can be blood, semen, meat/tissue, milk. The DNA sample taken from an animal as a reference sample can be later used to verify that animal at any time simply by comparing it to the test sample. This makes the animal fully traceable [22]. DNA traceability is also being used by the seafood and aquaculture industries to detect species fraud [23].

Necessity of Traceability in the Indian Food Industry

In the recent years Indian government has started to work on development of obligatory traceability system within the Indian food industry and food supply chain with private entities, state governments which include FSSAI, APEDA, NABARD, FPO, ITC's eChaupal, and Reliance industry etc. Traceability renders certain benefits such as it reduces public costs and private costs like product recalling [24]. It also decrease goods in stock, decrease distribution costs, decrease operating and storage costs, ensure quality of production and products, increase food safety and security , ensure consistent quality of food products, prevent food safety problems, gives accurate, timely, complete, and consistent information about products, reduces labor productivity losses, save time and money, reduce human error [25]. India at present requires more advancement in national food laws and ought to follow an effective traceability system in order to improve and change within current food industry and food supply chain.

Effective Traceability Techniques In India

Various product identification technologies prevalent in India are Barcode, Radio Frequency Identification (RFID) tags, alphanumerical codes, Hologram, and the geographical indication (GI) tag. In the upcoming years the newly developed food traceability techniques, such as global positioning system (GPS), bio tracing, nano sensor and geographic information system (GIS) would be adopted by India. The newly developed efficient traceability systems can minimise human error, spread more awareness about food quality standards and result in savings at some part in the supply chain [26]. With the increase in understanding for food safety among the consumers and government authorities the food traceability market is being increased in India. Cargill is planning to build a 100% traceable and sustainable supply chain of the palm oil in India by 2020 [27]. Similarly, McDonald restaurants have acquainted the food traceability

for potatoes to keep a track of the product sources from 40 different suppliers across the country with the aim to provide food safety and quality [28]. Tea Board of India has introduced Trustea and Rain Forest Alliance certifications. These certifications are compulsory for all tea manufacturers in order to set up the transparency and traceability in both domestic and overseas market. Only one tea factory Harrisons Malayalam Ltd (HML) has obtained all the desired certifications [29]. Some of the farm products like grape, mango, banana, onion, potato, soybean and poultry that are capable of increasing the economy of small farmers and changing the face of Indian farming sector are certified by APEDA and these can be easily traceable and identified in Indian market [30].

The various modern traceability systems presently being used in the Indian food industry are

1. **Alphanumerical codes:** Alphanumerical codes are a combination of the numeric and alphabetic characters of different sizes that is found on products label [31]. Alphanumeric codes are printed on reusable containers for easily identifying and supplying fast service to their customer [32].
2. **Bar code:** Barcode is an openly machine readable data that is printed on the objects whereas by means of electronics barcode, readers can easily encode, store and recall information [33]. Major food processing companies like Dabur food, Amul, Hindustan Unilever, Godrej beverages & foods, ITC, Kohinoor food, Mother dairies and Venkys India [34] are using the barcode and 2-D quick response (QR) code techniques with the aim to formulate an authentic product solutions and develop a trust in customers.
3. **Radio frequency identification (RFID):** In India this technique is being utilized by several dairy industries such as Amul dairy that utilises RFID tagging for milk yielding animal on their Anand farm in Gujarat. Chitale dairy which uses RFID tagging for tracking and storing information in relation to health issue and Govardhan dairy that utilizes this tagging for identifying their cattle by numbers from Maharashtra [35]. In India both domestic and foreign retailing players like Food bazaar, Tata sons, Wal-Mart, Metro, Reliance, Food bazaar, Tata sons, Future groups and Bharti have taken steps towards adopting RFID technology [36].
4. **Holograms:** It is a physical structure that diffracts light into an image and includes both the encoded material and the resulting image. It is also an effective product authentic solution which empowers brand owners, consumer and government authorities to quickly determine indubitable products against the fake one [37].

Initiatives of Traceability System in India

Initiatives of traceability for livestock

India has introduced cattle tagging using RFID for dairy farming and these have been adopted by the organizations like Amul, Gowardhan and Chitale dairy [35]. Chitale dairy has tagged around 7000 cows and buffaloes in Maharashtra and Tamil Nadu states respectively [38] and company has targets to capture all animals across the country because of increasing response from farmers and dairy companies [35]. Chitale dairy uses combine passive RFID tag to track cows and buffaloes which is fitted on each ear of cattle and buffaloes [39]. Combine passive RFID tag that is fitted on each ear of cattle and buffaloes is being used to track them. These tags are being used in chitale dairy.

Initiatives of meat products traceability under APEDA

A requirement of health certificate has been specified by APEDA for every company for exporting of the meat through Meat.net and has well-informed all the exporters that the export consignment must undergo through microbiological and other tests [40].

Initiatives for seafood traceability

Indian Society of Agribusiness Professionals [41] is planning to make Indian aqua farms for shrimps and other species fully traceable. Rajkumar Gollapalli, National Fish & Seafood Aquaculture and Sustainability specialist has reported that aquaculture traceability would bring a huge change, solve the critical work in moment and it is faster, easier, reliable and efficient [42].

Conclusion

Traceability is a critical component of quality assurance in the food industry. Animal identification is a key requirement for traceability within the livestock sector and is mandatory in many regions of the world. Such developments help to drive improvements in traceability technologies, are leading to more cost-effective solutions and ultimately to a broader uptake of traceability systems. The requirement of effective quality systems is reliability, integrity and traceability. Tracing of animals can provide greater confidence in certification schemes especially pertaining to their disease free status. The production of safe food involves a chain of responsibility and each participant in the chain from 'farm to fork' has a role to play to ensure food is safe. Traceability forms an essential component of any risk management strategy and is a key requirement for post-marketing surveillance.

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