Review Article

Livestock Traceability: An Overview

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Abstract

Traceability systems are record keeping procedures that show the path of a particular unit or batch of products, ingredients from supplier to consumers. Thus, completing the flow of food through documented identification and tracking, according to the concept "from farm to fork" and reversibly, "from plate to source". This system follows a products route from raw materials to the selling stage. It is a complete flow by means of identifying and tracking procedures. Before designing a system of traceability, one must identify the different characteristics that need to be traced throughout the various steps in the processing chain. Recently, traceability has gained significant importance as it allows efficient identification, correction or removal of risk factors throughout the process in order to deliver safe and quality products to consumers. Traceability includes harvesting, transportation, storage, processing, distribution and marketing (external traceability) and on the other hand, to trace the history of the product at any stage in the internal chain traceability. Traceability is eventually used to ascertain origin and ownership of livestock and agriculture products. It is a tool to help countries meet their objectives of controlling, surveillance, biosecurity protection of the national livestock population, preventing and eradicating animal diseases and to deter fraud, theft and misrepresentation of live animals. Traceability is adopted by major meat exporting and importing countries. This improves marketability of products in international market. There is a growing worldwide trend for countries to implement traceability systems for livestock tracing by RFID, barcode, QR code and is clearly the dominant technology being chosen to achieve this aim.

Key words: Livestock Traceability, Barcode, QR Code, RFID

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Introduction

Livestock sector is an important component of India's economy in terms of income, employment, foreign exchange. The value of the output of livestock sector from milk is ₹107,544 crores and ₹24,876 crores from meat. India is exporting quality and safe buffalo meat to about 64 countries like Vietnam, Kuwait, Malaysia etc. It is noticed that approximately 5,00,000 million tons of deboned meat is exported to other countries or approximately 50% of buffalo meat produces in the country is exported. It has more as new markets are being added each year (APEDA, 2017). India stood on 5th rank in world's meat production, estimated meat production is 6.3 million tones and accounts for 3% of total world meat production i.e., 220 million tones. The total meat production in the country is 7.0 million tons in the year 2015-16 which marks a significant progress in the meat production. Currently India has been exporting quality and safe meat to about 64 countries. India stands 1st rank in milk production in world. It contributes 163.7 million tons of milk annually. India has exported dairy products of 39,397.62 MT to the world (United Arab Emirates, Pakistan, Bangladesh, Bhutan and Nepal) for the worth of ₹910.44 crores during the year 2016-17 (BAHS, 2016). Any raw product of agriculture, animal husbandry or fisheries is transformed through a process involving employees, power, machines (technology) or money in such a way that its original physical properties undergo a change and if the transformed product is edible and has commercial value, it is termed as value added product. Then it comes within the domain of food processing industries. Significance of value addition is to increase the shelf life of products and prepare for consumption.

Concept of Traceability

The first international definition of traceability was given in 1987 as the ability to retrieve history, use or location of an entity by means of recorded identifications. The entity may designate: an activity, a process, a product, an organization or a person. The concept of traceability was introduced for quality assurance systems as a key element of any quality management product. Traceability as the ability to trace the history, application or location of that which is under consideration, adding that when considering product, traceability can relate to the origin of materials and parts, the processing history, distribution and location (Corina, 2013).

Traceability is an apparatus of control, a term that etymologically comes from the French "contre-rolle" (literally, "counter-roll"), designating the double of a document—a list, an account book—that is archived and used in order to verify the conformity of other copies. Control is defined primarily as an operation of verification by means of a system of written notation. Traceability systems are likely to detect raw materials or products, identifying them downstream and upstream of the production chain, the time and place of the technological flow. This is the ability to locate a product based on specific criteria, at any of its locations in the supply chain following backward or upward traceability (tracing). This is the way to identify the

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origin and characteristics of a product based on criteria established uniformly for all points of the distribution chain. In this approach traceability becomes the "big picture" that reflects the past (Smith *et al.*, 2005).

Tracking provides real-time data and current information on the status and location of a product. Traceability allows pursuing a products route by following a product from raw materials to marketing exposure, including its way to the final consumer and thus, completing the flow of food through documented identification and tracking, according to the concept "from farm to fork" and reversely, "from plate to source" (Trevarthen, 2007; Kumar *et al*., 2014). It is used for variety of reasons including verification of ownership, biosecurity control, record keeping, efficient farm management, registration, insurance and misrepresentation of theft of animals. Thus, proper tracing of animal is very important for understanding the need of record keeping and provide a base to improve the management of herd. Traceability and quality verification have become increasingly important in the animal production (Pankaj *et al*., 2007; Allen *et al*., 2008; Singh *et al*., 2014). This system facilitates trace back through the farm to slaughter stages of the industry and explores the feasibility and implications of extending the current identification system to a full chain traceability system from farm to fork. Three broadly defined roles of traceability (and quality verification) systems are as-

1. Improved management of food processing software: In food processing software, traceability systems imply the use of a unique piece of data (e.g., order date/time or a serialized sequence number, generally through the use of a barcode / RFID) which can be traced through the entire production flow, linking all sections of the business, including suppliers & future sales through the supply chain for correctness and completeness, using the traceability software to find the particular transaction and/or product within the supply chain (Corina, 2013).
2. Improvement of food safety or food supply chain and herd health problems: Supply chain illustrates the fact that the products they sell are manufactured in factories with safe working conditions, by workers that earn a fair wage, using methods that do not damage the environment (Golan *et al*., 2005).
3. Strengthening systems and software development strategies and providing stronger economic signals to producers: In systems and software development, in processing software, traceability implies use of a unique piece of data (e.g., order date/time or a serialized sequence number) which can be traced through the entire software flow of all relevant application programs. This is sometimes referred to as the transaction footprint (Dalvit *et al*., 2007).

Purpose of Traceability

a) To determine origin and ownership and to deter theft and misrepresentation of animals and animal products.
b) Surveillance, control and eradication of animal diseases.
c) Biosecurity protection of the national livestock population.
d) Increases international link.
e) Improvement of supply chain management, distribution, delivery systems and inventory controls.
f) To facilitate value-based marketing.

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g) To isolate the source and extent of quality-control and food-safety problems. It helps to improve collaboration, traceability, transparency, security, and visibility in the supply chain.

Basic Elements of Traceability

a) **Product Traceability** - determines the physical location of a product at any level in the food chain, in order to facilitate logistics management, product recall and dissemination of information to consumers and other stakeholders.
b) **Process Traceability** - defines the type and sequence of activities affecting product during growing and post-harvest operations.
c) **Genetic Traceability** - determines the genetic structure of the product, including information about the origin of genetically modified organisms (GMOs) or materials derived from GMOs.
d) **Inputs Traceability** - determines the type and origin of inputs such as fertilizers, irrigation water, livestock, feed, feed additives etc.
e) **Disease and Pest Traceability** - traces the epidemiology of pests and biotic hazards such as bacteria, viruses and other pathogens that may contaminate food and other products derived from agricultural raw materials (Opera, 2003).

Types of Traceability

Basically, two types of traceability are studied, and they are: forward traceability which maps requirements with test cases and backward traceability which maps test cases with requirements. The following subtypes can be distinguished:

1) Internal traceability represented by the information that allows product tracking within an organization. Internal traceability occurs when traceability partners receive one or more materials and ingredients that are subject to internal processing (within the organization). The development of an advanced internal traceability system can be stimulated by developing and implementing effective data storage, production process control and quality assurance.
2) External traceability represented by the information received or provided by the other members of the food chain on a particular product.
3) Chain Traceability i.e. traceability of the chain links, with a focus on information accompanying the product from one end to the other in its chain, so that traceability should be extended for any product at all stages of production, processing and distribution.

Traceability helps to restore the food chain from harvesting, transportation, storage, processing, distribution and marketing (external traceability) and on the other hand, the ability to trace the history of the product at any stage in the chain (internal traceability).

Characteristics of Traceability Systems

The basic characteristics of traceability systems are identification, information and connection between them. In practice, traceability systems consist of record keeping procedures that show the path of a product unit, a group of products or ingredients from a supplier. The steps are as follows:

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a) Identify units / batches of all ingredients and products.
b) Provide information about when and how products were sent and processed.
c) Configure a system that correlates the data.

Simple records, hand-written or printed labels are today quickly replaced by automated identification (e.g. bar codes and radio frequency tags). In this way, the information that can be identified and provided by such systems has increased significantly.

Advantages of Traceability

1) **Animal health protection**- Protection of animal health burden is mainly farmer's responsibility, as their interest is to keep animals in a very good state of health in order to avoid economic loss. Health status such as vaccination, deworming, diseases testing, and treatments is effectively maintained.
2) **Animal disease control**- As traceability serves to immediately trace the source on the one hand, and on the other hand to check all links in the processing chain which excludes transferring animal diseases to humans.
3) **Protection of human safety**- This is favored by the traceability system for multiple reasons as exclusion from slaughtering of diseased animals or animals suspected of infectious and contagious diseases for public consumption and selling meat products and by-products derived from such animals.
4) **Fraud control**- Traceability along with regular records audits can prevent fraud on the products origin, on the species of organisms used to obtain a product and allows verifying the truthfulness of statements about raw materials or products. This will improve marketability of products in international market.
5) **Facilitating withdrawal**- Traceability allows the determination of control measures to prevent or reduce an identified hazard, in the event that an incident endangered the safety of consumers has occurred.
6) **Developing food contaminants monitoring programs**- Traceability facilitates the identification of key products in a food chain where product sampling is necessary to monitor the concentration of chemical.
7) **Risk assessment from exposure to food**- This can be easily demonstrated by correlating information from traceability records of the system and animal related information online.

Process of Traceability

The process of ensuring traceability takes place in four stages-

Stage 1	Identification of animal and premises that have been subjected to the same production and processing.
Stage 2	Recording information on the production process
Stage 3	Establishing links between economic operator in the chain, agriculture, manufacturer, distributor, point of sale that must be able to provide documented evidence of the link between batches, suppliers and customers.
Stage 4	Communication- every economic operator in the chain communicates the identification elements of the lot to enable the continuous implementation of the traceability principles.

Identification of Animals

Identification of animals can be defined as "the combination and linking of the identification and registration of an animal individually, with a unique group identifier." Animal identification refers to

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keeping records on individual farm animals or groups of farm animals so that they can be easily tracked from their birth through the marketing chain. Historically, animal identification was used to indicate ownership and prevent theft, but the reasons for identifying and tracking animals have evolved to include rapid response to animal health and food safety concerns (Moreki *et al.*, 2012). Traceability in farm origin is becoming increasingly important to consumers and producers. Traceability systems would be greatly facilitated by electronic animal identification. Permanent and reliable animal identification is a primary goal for the implementation of animal traceability systems. Electronic identification (e-ID) by using radio frequency (RFID) passive transponders improves traceability due to faster monitoring of livestock and easier management of databases for inventory and movements between premises (Singh *et al*., 2014).

Methods of Identification

There are various existing methods of animal identification which has their own advantages and disadvantages.

Conventional Methods

1) Tagging
2) Ear notching
3) Branding
4) Tattooing

Demerits of Conventional Methods

a) Conventional method is not suitable for all animals and can be replicate/counterfeit.
b) Ear notching leads to the development of ear wounds.
c) In case of ear tagging, tags get smeared when animal approaches to mud. The mud and manure makes this method unsuccessful and they are also lost frequently.
d) Tattooing method need close observations for identification and cannot read without catching head of the animal.
e) Branding method of identification leads to cruelty against animals. It develops permanent marks on the skin and is very painful to the animals (Schwartkopf-Genswein, 1999).
f) Branding decreases hide value for the tanning industry due to severe damage to the skin.

Biometric Methods

Biometrics are non-invasive methods for identification of animals. An animal biometric identifier is any measurable, robust and distinctive physical, anatomical or molecular trait that can be used to uniquely identify or verify the claimed identity of an animal (Barron *et al.*, 2009). The methods are:

1) Muzzle prints

This method has been used to identify the animal on the basis of the arrangement and distribution of ridges and valleys on the muzzle (Ebert, 2006; Pankaj *et al*., 2010). The prints of muzzle are taken from the

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individual animals are examined for the various muzzle characteristics and recorded in table for future reference.

2) Retinal imaging

Retinal imaging can be used for identification of animals. An image of the blood vessels pattern on the retina is similar to that of fingerprint. This pattern fixes at birth and does not change throughout the animal's lifetime. Using a computer algorithm, the retinal image is converted into unique identification. Retinal imaging and muzzle-prints of sheep and cattle were compared, and muzzle prints were found to be a quicker method than retinal scanning (Howell *et al*., 2008) however, retinal scans are easy to analyze by inexperience operators.

Electronic Methods

The electronic methods are as:

1) Bar Coding

Barcodes are symbols that can be scanned electronically using laser or camera-based systems. They carry information about the object to which it is attached in a machine-readable format. As opposed to manual data entry, which is tedious and prone to inaccuracies, barcodes enable automatic data capture with 100% accuracy.

2) Radio Frequency Identification Device (RFID)

Radio frequency identification is a method of recording a unique number that has been assigned to an electronic identification device carried by an animal. This provides each animal in the flock with its own individual identification number and forms part of the National Livestock Identification System (NLIS). RFID technology can be used as a means of tracking animals on property through sale yards, feedlots and abattoirs to provide traceability. It may also be used on-farm to collect individual performance data such as weaning weights or used in conjunction with an automated machine milking system. Electronic identification (EID) of animal involves using RFID devices that can be carried externally on the animal such as an ear tag or internally with an RFID bolus. RFID technology is quick, easy and accurate. It is more efficient in time management and saves labour cost. It is a data storage device and data can be easily viewed, analyzed, manipulated and sorted (Finkenzeller, 1991).

How RFID Works

The working of RFID is explained below-

The scanning antennas can be permanently affixed to a surface. Handheld antennas are also available. We can fix them into a door frame to accept data from persons or objects passing through it. When a RFID tag

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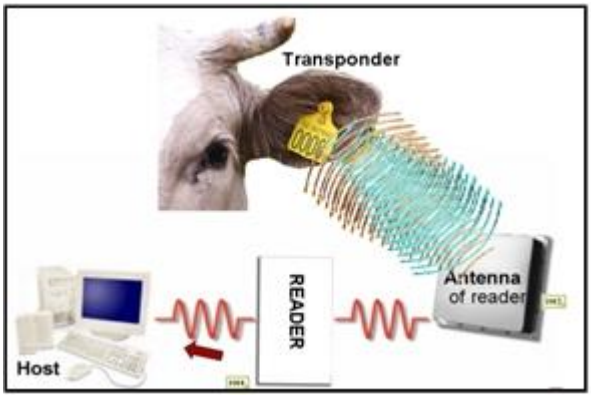
passes through the field of the scanning antenna, it detects the activation signal from the antenna, that "wakes up" the RFID chip, and it transmits the information on its microchip to be picked up by the scanning antenna (Kampers *et al.*, 1999; Singh *et al.*, 2014).



RFID tags are of two types. Active RFID tags have their own power source and the readers can get the signal from a distance however, life span of this device is less than 10 years. Active tags usually operate at frequencies of 455MHz and have a readable range of about 20 to 100 meters. Passive RFID tags do not require batteries and are smaller in size and have a virtually unlimited life span (Tan *et al*., 2007).

Radio Frequency Identification (RFID) is most common and latest technology which is used for the identification of livestock. RFID consist of three components and they are as follows:

(1) Transponder (2) Transreceiver (3) Herdmans software (data accumulator) (McAllister *et al*., 2000).

1)Transponder: Transponder is implanted inside the body. Transponders have a silicon chip and an antenna. Silicon chip have 12 digits for identification of animals. Transponder can be of any type-

Ear Tags: The ear tag transponder is one inch in diameter and can be embedded in plastic (Stark *et al*., 1998).

Bolus: The bolus transponders are covered by a capsule of biomedical glass and injected under the skin or introduced orally into the fore stomach of ruminants through a balling gun. Bolus is irretrievable until the time of slaughter. Boluses show higher readability (99.5 MHz) than visual tag (89.8%) (Garin *et al.*, 2005).

Collar: Electronic collar are similar to that of neck chain, except that they have an attached tag with an electronic number that can be read by a scanner. Electronic collars are easy to use, but they can cause a choking if they are not adjusted properly to the growth of the animal or if they become hooked on protrusions.

Microchips: Microchip is a form of identification that involves the implanting of an electronic chip, with a miniature radio transponder and antenna, under the skin of an animal near the neck between the shoulder blades, or near the base of the ear.

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Each of these devices provides the same functionality, reliability, accuracy, and is intended to last for the lifetime of the animal.

2) Transreceiver/ Reader/ Scanner: The transreceiver is a device which sends an electronic signal to the tag, the tag gets charged and replies with the stored information. There are two basic readers (1) Portable/ handheld and (2) Fixed reader.

Fixed RFID Reader: Fixed RFID reader is used at a position in which a farmer wishes to utilize an animal RFID number on a regular basis. These provide a reliable and robust source of identification. These can be used in conjunction with other devices to enable a subsequent action or series of actions to be performed, or decisions to be automatically made. For example, fixed readers may be utilized for the-

(1) Purposes of identifying an animal as soon as it enters the milking parlor, and subsequently recording the time and date.
(2) To record a milk production (in association with milk meters).
(3) To identify animals required for drafting gate operations etc.
(4) Provides the possibility for the basis for a wide range of optional operations to be conducted within the dairy that require individual identification of animal (e.g. automatic feeding etc).

Portable RFID Reader/Handheld Reader: The handheld reader can be powered by a rechargeable battery. Portable readers are capable of reading the RFID tag of an animal in the field and displaying the animal's RFID number on a small digital screen in-built into the portable reader, and possibly providing an audible reading of the identification number.

Source: (Singh *et al*., 2014)

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A portable RFID reader could be attached to a personal digital assistant (PDA) which is loaded with a herd management software and the data stored on the farms central herd management software application can be copied to this PDA thus, effectively providing a mobile copy of the herd information. Utilizing this arrangement, the farmer can then scan a RFID tag with the portable RFID scanner and the identity and

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information pertaining to that can be provided on the screen of the PDA. The farmer can use the PDA similar to how they would utilize their host desktop computer, being able to browse the animal's information and should also be allowed to record and update animal information on-site (Kamper *et al*., 1991).

3) Herdman Software: It consists of laptop and computer which work as data accumulator. It contains the software that allows communication with the readers. This is required for the communication with data accumulator, where software is necessary. Herd management software provides mechanisms for farmers to store individual cow data into a database. Data can be entered into this software application manually via an easy to use, standardized interface, or alternatively, data can be automatically entered through the use of other digital devices (such as milk parameters, animal weight scales) linked to this database. Such herd management software also provides RFID devices with the information required to make a decision or conduct an action.

Digital Device Network – Wireless/ Wired/ Hybrid: A digital device network is required to enable the communication of devices between one another that is RFID readers and the central herd management software. There are essentially three methods of establishing such a network – wired, wireless or hybrid. The selection of the implementation type will depend upon the characteristics and preferences of individual dairy farms (Treventham and Michael, 2008).

Now a day's farmers are utilizing wireless networks. This will enable an array of devices, to be linked directly to real-time data in the herd management database. Various devices include the mainstream computer network devices, such as PDAs, laptops, desktop personal computers and printers also provide the vital links to dairy farm devices, such as RFID readers, milking controller units, feed management units, drafting gates etc. A hybrid network involves some components of the network utilizing direct wired connections to the herd management software and server application, while other devices are provided with portable abilities. This may be the preferred option where there are devices that are intended to be permanently placed in a position, while other devices require portability. Utilizing the hybrid approach, portable devices can be connected to the network and subsequently the central herd management database at regular intervals, where they can download the latest information from the central herd management database.

The farmer can remove these devices from the network and take this device with them out into the field, where they can use this device to view, record updates or modify existing data. However, any changes made will only be reflected in their local portable version of the database at the time of recording. The farmer must then return to base and attach the device to the central network again to upload the data they recorded while in the field. The decision of using wireless, wired or hybrid networks must be based on the

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requirements and a cost-benefit analysis. It is believed that as wireless technologies advance in the future, providing greater capability and new functions and even greater range of abilities in the future reducing cost.

Premises Identification

Premises identification is one of the basic elements of livestock traceability. Premises are defined by a legal land description of the lot or in its absence, by its geo-coordinates. It is needed to report animal movements to the national traceability database. The premises identification number may be required in other areas of your business, for example: tag purchases, for lab samples or for funding. Premises are any parcel of land on which animals, plants or food are grown, kept, assembled or disposed. Premises identification includes the following:

i. Pastures and community pastures
ii. Assembly yards
iii. Abattoirs
iv. Auction and livestock sale facilities
v. Exhibitions and fairgrounds
vi. Veterinary facilities
vii. Zoos and wild animals

Premises identification number is a permanent unique identification, based on national standards, that is assigned by provincial governments to "premises" within a province or territory. Premises identification number links livestock and land locations. Premises identification number must meet the national standard format, like 2 letters for the province and 6 alpha-numeric characters. Premises identification number is the only location identifier for animal movement reporting. The identification of premises is the responsibility of the provincial government. Producers must contact their provincial association or their provincial department of agriculture directly to obtain their premises identification number (Pineda-krch *et al*., 2010). Animal movement refers to any activity when animal is taken from where it is kept (location of departure) and brought to another location (location of arrival). Any animal moving into your facilities is considered to be an animal movement even for a short journey. The following information is the minimum requirement for animal move-in records & reports:

i. Animal identification number – 12 digits.
ii. Date of animal's arrival.
iii. Premises identification number of the farm of arrival and departure.
iv. License number, slaughterhouse number, and registered veterinary doctor.

For animal imports, premises identification number of the farm of departure might not be known by the producer who is receiving the animal. In those cases, the producer may report the location of the site where

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the animal was kept before it was imported (e.g. address of the facility). Animal movement information might be recorded in an on-farm paper manifest, herd management software, excel document, provided templates. It should be kept on farm for a minimum of five years for further reference.

Traceability System at Farm Level

The system is driven by the government's strategy for eradication of diseases, food safety and for providing consumer confidence.

a) **Identifying Reporting-** Keepers must apply both ear tags, which bear 12 digits original identification number (12 digits). Movements of animals between different properties are required to be registered and both the sender and recipient are obligated to record details.
b) **Information-** This is required to maintain a holding register that contains the following information; identification number, date of birth and sex, date of arrival and previous holding for purchased animals, data of departure, holding of destination in case of exit and data of death for fallen animal (stored in 12 digit code).
c) **Labeling-** Beef identification numbers labeling is applied at each stage of the processing chain > Slaughterhouse > Wholesalers > Retails > Certain Restaurants. Identification numbers must be indicated to be clearly readable for purchasers and consumers.
d) **Ensuring-** All suspected animals can be tracked to eradicate if any disease outbreak occurs. The database can supply at any time a list of identification numbers for all suspected animals. The competent authority takes preventive measures on the basis of this database.

Tracking System

It is a combination of GPS (global positioning system) and RFID technology. This will help in enhancing farm management capabilities. It is proposed that GPS technology included in RFID tags is used in tracing animal movements and locate individual animal with a single program (Karnjanatwe, 2005). Obviously, with a small herd size, this is not a particularly prominent issue (as farmers will be able to know locations from their own knowledge of the herd and movements), however as herd size increases, GPS location ability becomes increasingly valuable. This ability is further enhanced as the farmer may be able to use a PDA or other mobile device to display a map of their farm and pinpoint the animal location within this farm layout. Utilizing this approach, farmers can be guided to the exact location of any animal they desire (Tan *et al*., 2007). It is in farmer's best interest to minimize the risk of such incidents, which a GPS system utilizing plotted boundaries can facilitate. Similarly, the combination of GPS with RFID will aid to prevent and detect any theft of animal. Additionally, proof of identification and ownership of each animal can be provided via the RFID capability of such devices.

Furthermore, software could be designed to detect individual animal movement that may be considered out of the ordinary. If an animal is moving significantly less than usual, this could be a strong sign of illness, and certainly something worthy of a farmer's investigation. Additionally, this tracking may also be used as a mechanism for detecting when animals are in heat. Thus, if an animal's movement is detected to be

abnormally high, this may be a strong sign that she is in heat, and thus, notification of this should be provided to the farmer.

Steps of Tracking System

a. **Collaborate with Suppliers-** Retailers need to ensure their suppliers have systems and software in place for forward and backward lot tracing, and the ability to easily link lot numbers with recalled ingredients. Suppliers should be able to determine when a lot was received in inventory and where the lot was consumed in the manufacturing process. This allows them to link the lot to the finished product's bar-code label. If a product is recalled, the supplier can use its systems to identify the finished goods that were produced with the ingredient lot and notify customers who purchased those goods.
b. **Implement Tracking Systems and Software-** Traceability is about tracking and recording product movement. Organizations can use tools such as lot codes, bar codes, and RFID to track goods. Once a system is in place, a retailer who is notified that a recall for a particular lot has been initiated can pinpoint exactly where these products are within the supply chain.
c. **Integrate Traceability with Existing Technology-** There are existing systems to record the transformation and movement of goods from the warehouse to stores. Many warehouse management and order preparation systems can be used to record lot numbers and other essential information.
d. **Creates an Alert System-** With an effective event monitoring system, companies can notify managers across the supply chain when an incident occurs. This enables retailers to freeze inventory, whether it's in the store, the warehouse, or in transit. By linking these alerts to retailers' point of sale systems, they can also prevent further sales of the affected product.
e. **Communicate with Customers-** Retailers can use customer loyalty programs, such as rewards cards, to inform customers about product recalls. More retailers are taking advantage of these programs to send messages about contaminated products. Speedy alerts to customers can help further contain a recall. All over the world, there are many approaches for unique identification of food using different types of identifiers, hardware and software solutions. Several means of product identification are presented below. Electronic tags can be attached to boxes, racks, machines and are used to carry traceability information in a format that can be read remotely.
f. **Serial Number and a Lot Number**- Tracking of serial and lot numbers is an important part of the supply chain process and getting products from manufacturer to consumer, safely and accurately. A serial number is a unique number assigned to identify a specific item. A lot number is an identification number assigned to products indicating the batch or lot in which the product was manufactured or processed. Serial number tracking & lot number tracking is the ability to track and trace serial numbers back to suppliers, through distributors or to customers by lot or batch (Rea, 2011).

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Tracking by barcode technology and software with bar coding, lot numbers can be recognized when received, shipped or both, enabling products to be tracked and traced throughout the supply chain.

g. Role of Barcode Scanning / Mobile Technology in Inventory Traceability

It is read by physically bouncing a narrow beam of light on the code, which can be interpreted using the pattern of light reflected off the white gaps between the lines. Barcodes are symbols that can be scanned electronically using laser or camera-based systems.

They carry information about the object to which it is attached in a machine-readable format. Bar codes (including 2D) originally applied only to products in order to identify them in the marketing chain, have been used for several years for traceability purposes related to raw materials processing. It is very beneficial to use barcode scanning for tracking and tracing inventory to record a lot of batch numbers. A small mistake in entering the numbers into the system can throw off entire traceability chain. Barcode scanning will speed up the process to eliminate costly mistakes to inaccuracies. Barcodes enable automatic data capture with 100% accuracy (Stancu, 2010).

h. QR Code (**Quick Response Code**) is the trademark for a type of matrix barcode (2D dimensional barcode), first designed for the automotive industry in Japan. QR code uses four standardized encoding modes i.e. numeric, alphanumeric, byte/ binary, and kanji to efficiently store data. It reads fast and has a greater storage capacity as compared to barcode. QR code consists of black squares arranged in a square grid on a white background, which can be read by an imaging device such as a camera. It is readable by smartphones and not by laser light. It allows to encode over 4000 characters in a two-dimensional barcode. The content of a QR code cannot be changed once generated, until the images can be appropriately interpreted. The required data is then extracted from patterns that are present in both horizontal and vertical components of the image (Anonymous, 2017).

World Perspective

The National Livestock Identification System **(**NLIS) is a national program run under the auspices of safe meat. The government and industry partnership are responsible for red meat safety and integrity. The program is conducted by meat and livestock. This structure is different to nearly all other countries implementing permanent identification schemes where the programs run by government regulatory programs. The NLIS has a number of industry-based committees responsible for the policy direction and technical standards. The system is presently working in Australia, New Zealand, Canada, Japan, Brazil, Uruguay, Botswana, United States of America (USA) and European Union (EU). All cattle must be identified with NLIS devices prior to leaving their property of birth. Requirements for all devices to be read at abattoirs and sale yards, and all movement transactions need to be recorded on the national database. The objectives of the NLIS are:

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i. Enable government agencies and industry to respond quickly and effectively to future livestock disease, chemical residue and food safety incident.
ii. Enhance and support quality assurance, genetic improvement and disease control programs.
iii. Enhancing arrangements for preventing livestock theft and identifying stolen animals.
iv. Improve on-farm productivity by facilitating better herd monitoring and management.
v. Improve the efficiency of data exchange between all sectors of industry including carcass feedback data.

Indian Perspective

The National Livestock Identification System **(**NLIS) is a national program running in some states of India like Maharashtra, Andhra Pradesh, Gujarat and Madhya Pradesh (Dandage *et al*., 2016).

a) Tracenet

Enhancing the credibility of certification system for livestock products, a user-friendly web-based traceability system (Tracenet) has been implemented by APEDA since June 2010**.** Tracenet software is being provided for use by the operators and certification bodies. APEDA has further initiated the steps to extend the present traceability system from certification to the accreditation process. It is used in all livestock products like meat, poultry, dairy, honey and aquaculture products and tends to increase after the standards are notified in the near future. APEDA has already initiated steps to extend the present traceability software from certification to the accreditation process. For efficient monitoring, GPS system is used at the farm level by the inspecting body. Every harvested lot at the farms up to the level of the consignment exported can be traced back. Implementation of tracenet has reduced the documentation work and has been saving time in the entire process with efficient control. The importing countries have appreciated the present certification module "Tracenet" and it has provided substantial publicity in the credibility of not only the certification bodies but also of the entire certification system in the country.

Tracenet helps generate confidence among global buyers and consumers about the genuineness of Indian product and indirectly helps every stake holder in the supply chain, from exporter to the farmer and gets the desired value for their produce. It also provides a level playing field for all stake holders in the supply chain, among farmers, processors, grower groups and certification bodies.

Conclusion

Traceability is part of the reactive control system for risk management. A traceability system provides answers to the following questions: when? where? which type? how much was produced? by whom? who participated? and in what production phase of the product? Tracking is the retrieval of the actual status of a shipment, a package etc. Tracking is the ability to follow the path of a specified unit or batch of a product downstream through the supply chain as it moves between trading partners. Products are tracked routinely for availability, inventory management and logistical purposes. Traceability, as it is designed and used in

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food production practices, is a key element of transparency. The traceability associated with an information flow is a physical process and integrated into the quality system, records animal related information online such as production data, reproduction data (artificial insemination, pregnancy diagnosis, calving) and health status (vaccination, diseases testing, treatment) etc. So, careful planning is essential for ensuring traceability throughout the food chain, taking into consideration the need to create consensus among the food operators and to gain consumers trust. It promotes the livestock sector.

Our country must observe changes happening in livestock sector and must take immediate action to transform to face the challenges. Increased penetration of internet and mobile connectivity has opened up several opportunities to transform agricultural sector having highest number of livestock in the world. Country must also exploit its potential in the international market. There is an urgent need to integrate and bring all traceability initiatives of the country under one umbrella at national level to promote traceability in the country. Traceability framework is still developing.

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