DEVELOPMENT OF A FARM TO CONSUMER TRACEABILITY MODEL
FY 2011

Michigan was the first State in the U.S. to adopt a mandatory radio frequency identification (**RFID**) tracking system for cattle in response to an outbreak of bovine tuberculosis in some of the State's herds in 2007. In the event a cow or steer is diagnosed with the disease, State health officials can access the database to locate and remove from commerce any cattle that have been exposed to the infected animal.

Researchers at Michigan State University (MSU) have several initiatives aimed at developing local and regional beef production and marketing systems in Michigan. FSMIP awarded MSU a matching grant for a pilot project investigating adoption of traceability technology for its potential to both to expand markets for mid-sized beef producers and meet consumer demand for information about the origin and characteristics of their food. The objective was to study the process of translating information contained on the RFID ear tag to a two-dimensional (2D) barcode label that would be placed initially on the carcass and eventually onto each piece of packaged meat destined for the end user. 2D barcodes can store large amounts of information as machine-readable, black and white patterns, rather than lines and spaces as used in single dimension barcodes. Initially invented to improve data capacity for industrial applications, 2D barcodes can operate as portable databases when scanned and decoded by camera-equipped mobile devices, with promising applications for providing a host of data about an individual animal.

Results showed that the process caused little or no disruption of the routine tasks in both the harvest and processing facilities. The transfer of RFID data to 2D labels resulted in 100% accuracy in tracing the beef through the supply chain. Based on the modest cost of the systems tested, it appears that relatively simple traceability systems could be developed costing 1 to 2% of wholesale value. Further study is needed to define the specific characteristics that consumers desire and value about locally and regionally produced beef that could be contained in the 2D barcode.

FINAL REPORT

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DEVELOPMENT OF A FARM TO CONSUMER TRACEABILITY MODEL

UTILIZING RADIO FREQUENCY IDENTIFICATION, 2D BARCODES, AND WEB ACCESSIBLE DATABASE ● FY 2011

Final Project Report Prepared for:
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BACKGROUND AND PROBLEM STATEMENT

Mid-sized farms are declining at an alarming rate in the U.S. A clear market opportunity for many mid-sized farms is to produce differentiated products, with specific desirable attributes, for "*local*" consumers. The challenge – mid-sized farms typically are too large to dedicate the time and resources needed for direct marketing of their products to consumers, yet they are too small to be incorporated into vertically integrated brands. The lack of applicable and convenient methods to track farm and/or product attributes (including product origin) through modern supply chains has been recognized as a market barrier (Martinez et al., 2010). Product traceability, tied to farm and/or product attributes, offers a way to enhance mid-sized farm market opportunities and resulting economic viability.

MID-SIZED FARMS ARE DISAPPEARING

Optimized future food systems will likely embrace a variety of supply chain size strategies to be effective (Lusk et al., 2003; Born and Purcell, 2006). However, distribution of U.S. farm size, based on value of agricultural products sold, is becoming more and more skewed. That is, the number of large farms (> $500,000 in sales), and very small farms (< $2,500 in sales) continue to grow, while the number of all other (mid-sized) farms continue to decline in number (USDA-NASS, 2012, 1997; Welsh, 2008). In 1997, there were 1,452,442 mid-sized farms in the U.S., but alarmingly, this number had dropped by 20% just 15 years later (USDA-NASS, 2012). "*Agriculture of the middle*" is described by Kirschenmann and coworkers (2004) as a market-structure phenomenon, where a farm's market falls between vertically-integrated commodity markets, and direct-to-consumer markets. It is this "*agriculture of the middle*" that is most vulnerable to polarized markets, because they are too small to compete in consolidated commodity markets, and too large to practically sell in direct-to-consumer markets. Ironically, given these vulnerabilities, mid-sized farms likely have a comparative advantage in producing unique, highly differentiated products. What is missing is a functional value chain to connect these farmers to consumers (Kirschenmann et al., 2004).

GROWING INTEREST IN LOCAL FOOD AND SMALL AND MID-SIZED FOOD SUPPLY CHAINS

There is a movement by consumers, agricultural producers, academia, and governments to reexamine the types and scales of current food production, distribution, and marketing systems. 'Local food' advocates suggest that shortening food supply chains may help to improve food safety and quality, reduce environmental impacts, strengthen local economies, and better provide food security. Irrespective of these suggested benefits, of particular interest to farmers is the prospect of receiving a greater share of revenue from local food supply chains than from mainstream chains. In local supply chains, producer net revenue per unit has been shown to range from about equal, to more than seven times the price received in mainstream chains (King et al., 2010). Martinez, et al., (2010) described that barriers to local food-market entry and expansion include lack of distribution systems for

moving local food into mainstream markets. The 2014 Farm Bill includes policies and programs designed specifically to increase the supply of and demand for local food (113thCongress, 2014). The Farm Bill provides additional resources for farmers market and local food promotion, business loans for locally- and regionally-focused businesses, and value added product market development, at least in part, to stem the tide of losing agriculture of the middle.

UNTAPPED VALUE OF BEEF CREDENCE ATTRIBUTES

Differentiation of "*local*" food is based on attributes other than simply local origin, such as producer values and production methods employed (Marsden et al., 2000; King et al., 2010). Caswell and Mojduszka (1996) categorized food product traits as search, experience, or credence attributes. According to their definitions, search attributes can be identified before purchase through inspection or research (*e.g.* marbling, lean color, external fat); experience attributes can be determined after consuming the product (*e.g.* juiciness, tenderness, flavor); and credence attributes cannot be assessed even after the product is purchased and consumed (*e.g.* locally produced, grass-fed, organic, or humanely raised). The number of imaginable credence attributes is directly related to the growing consumer interest in food origin and processes. Labeling food with verified credence attributes would enable real choice to be exercised among foods produced in different ways.

There is a growing body of research examining the value of beef credence attributes such as grass or forage fed (Martin and Rogers, 2004; McCluskey et al., 2005; Umberger et al., 2009), no added hormones given (Lusk et al., 2003; Ward et al., 2008; Umberger et al., 2009), no antibiotics used (Ward et al., 2008; Umberger et al., 2009), genetically modified corn fed (Lusk et al., 2003), all natural (Ward et al., 2008), source verified (Ward et al., 2008), locally produced (Maynard et al., 2003; Alfnes and Sharma, 2010), and generally branded (Parcell and Schroeder, 2007). A consumer survey, exploring the value of beef credence claims, found that a majority of consumers were skeptical about the validity of credence claims. Nevertheless, roughly one half of consumers surveyed were willing to pay a premium of $1 to $4/lb for the credence attributes of (percentage of consumers willing to pay premium) no antibiotics used (56%), naturally raised (52%), produced-in-state (54%), organic (49%), humanely raised (50%), raised on family farms (55%), grassfed (51%), source verified/traceable (48%), corn fed (50%), no hormones (54%), sustainably raised (49%), vegetarian fed (46%), no pesticides (55%), and free range (48%)(NCBA, 2010). Relaying information about credence attributes to consumers is straightforward in the case of direct-to-consumer marketing. In stark contrast, the lack of viable methods and logistics to provide consumers with credence attribute information is a market barrier for agriculture of the middle. Currently, value-added opportunities are limited for mid-sized beef farms due to lack of product information tracking throughout the supply chain. Adding value to products via credence attribute information is only possible through preserving identity from creation of the attribute until the product reaches the consumer. Lack of or imperfect information leads to markets that do not work well and consumers who may lose confidence and trust in the quality of the food system (Jensen, 2006).

THE CASE FOR BEEF TRACEABILITY

In addition to food safety and supply management, a primary driver for beef product marketers to develop traceability systems is to differentiate and market foods with credence attributes (Golan et al., 2004). Traceability is the capacity to follow the movement of a food through specified stages of production, processing and distribution (ISO 22005:2007(E), 2007). New methods and technologies may provide ways to portray a large amount of easily understandable information and allow consumers to move from summary information on the label to more complete information available electronically (Jensen, 2006). Emerging technology offers the prospect of increasing the technical and economic feasibility of animal and product data collection and tracking. Machine-readable identification provides the ability to greatly enhance traceability systems (FSA-UK, 2002).

Recently, a meat and poultry industry consortium developed a guide of best practices to share information between trading partners (mpXML, 2010). The practices outlined rely on the GS1 Global Traceability Standard (**GTS**) (GS1, 2009), which defines information that must be collected, recorded, and shared to ensure "*one step up, one step down*" traceability. Therefore, supply chain traceability in this standard relies on each partner maintaining and sharing the appropriate records. As part of the GTS, adoption of one dimensional barcode formats (GS1 Databar and GS1-128) encoding the Global Trade Item Number (**GTIN**) and batch/lot number is designed to enhance effectiveness of meat and poultry product recalls (GS1, 2009). Although the practices covered in thempXML guide (mpXML, 2010) span all levels of product hierarchy, the structure does not include real-time traceability to farm of origin, nor does it attempt to address animal traceability, or product attributes.

USE OF TWO-DIMENSIONAL (2D) BARCODES IN TRACEABILITY

Two-dimensional (**2D**) barcodes (or tags) can store large amounts of information as machine-readable, black and white patterns, rather than lines and spaces as used in single dimension barcodes. Initially invented to improve data capacity for industrial applications, 2D barcodes can operate as portable databases when scanned and decoded by camera-equipped mobile devices. Decoding alphanumeric data in 2D codes allows users to access information anytime, anywhere, regardless of network connectivity (Kato and Tan, 2007). 2D barcodes can also encode Uniform Resource Locators (URL), thereby pointing to virtually any type of online digital media. There are a wide array of 2D barcoding symbologies (Adams, 2009); examples of four common symbologies are described in Table 1.

Table 1. Capacity, features, and standards for major 2D barcodes[a]

	QR Code	PDF417	DataMatrix	Maxi Code
Example code[b]				
Developer (country)	DENSO (Japan)	Symbol Technologies (USA)	RVSI Acuity CiMatrix (USA)	UPS (USA)
Numeric	7,089	2,710	3,116	138
Alphanumeric	4,296	1,850	2,355	93
Binary	2,953	1,018	1,556	
Features	Large capacity Small printout size High speed scan	Large capacity	Small printout size	High speed scan
Standards	AIM International JIS ISO	AIM International ISO	AIM International ISO	AIM International ISO

[a]Adapted from Gao et al., (2007).
[b]The word "*traceability*" encoded in the various 2D barcodes.

2D barcodes are increasingly used in Japan as a component in food traceability systems. Systems using 2D barcodes have been reported for tracking Japanese produce (Kato and Tan, 2007; Sugahara, 2009; Hall, 2010) and fish (Seine et al., 2004). The Japanese government and Japan Agricultural Cooperatives have actively promoted development and application of food traceability systems as national projects since 2001. The traceability systems are based on an identification (**ID**) number being assigned to a unit or lot of food products. The ID is printed on the products or packages. Farmers input production data about their products in an internet-accessible database.

Consumers can then browse the products' data by accessing the database using the product ID (Sugahara, 2009). Traceable food in Japan is often referred to as ''*food with a visible face*" (Hall, 2010). Ishii and Takeyasu (2006) found that a large number of Japanese consumers preferred getting information provided by a traceability system through home computers (45%), store computer terminals (35%), or by smartphone scanning of 2D barcodes (17%).

AN OPPORTUNITY TO MODEL A TRACEABILITY SYSTEM

Michigan was the first state in the U.S. to adopt a mandatory radio frequency identification (**RFID**)-based animal tracking system (Kirk and Buskirk, 2006). The system consists of a unique premises identification, mandatory unique official USDA RFID of all cattle prior to leaving the premises of origin (Buskirk, 2006), and tracking of animals that are "*sighted*" during routine testing for bovine tuberculosis, movement through livestock markets and (or) arrival at regional processing facilities (Grooms, 2007). Individual animal traceback and trace forward data are securely stored in a database (USAHerds; http://usaherds.org) for access by state animal health officials.

The current project dovetails within a larger framework of developing novel local and regional beef production and marketing systems in Michigan. An effort was launched within this larger initiative, the aim of which is to produce and market local beef at a mainstream market scale. Beef cattle born at the Michigan State University Upper Peninsula Agricultural Research and Extension Center, Chatham, MI and the Beef Cow/Calf Teaching and Research Center, E. Lansing, MI are being finished at the Beef Cattle Teaching and Research Center, E. Lansing, MI. Cattle are then harvested by Ebels Meat Processing, Falmouth, MI, processed by Byron Center Meats, Byron Center, MI, distributed by Sysco, Grand Rapids, MI, and consumed through Michigan State University's Division of Residential and Hospitality Services. The goal of this initiative is to lower the real and perceived barriers for marketing local beef at a sizeable mainstream scale by development of a model template appropriate for replication. This initiative is a multi-stage process, with the initial work partially supported by funding from the Michigan Animal Agriculture Initiative. The next stage in the process is the project reported herein, which was to design and develop a beef traceability model aligned with further development and expansion of the model.

PROJECT APPROACH

The project was structured around the following 5 major objectives:

OBJECTIVES 1 AND 2: CREATE AN INTERNET ACCESSIBLE DATABASE FOR ENTRY AND RETRIEVAL OF FARM AND ANIMAL ATTRIBUTES; DEVELOP A USER INTERFACE FOR PRODUCER ENTRY AND CONSUMER RETRIEVAL OF DATA

A pilot beef traceability project was conducted using ten steers and their beef (Buskirk et al., 2013). Information regarding the individual cattle including RFID number, breed, gender, and birth date were entered into a web accessible recordkeeping system (ScoringSystem, Bradenton, FL; https://www.scoringag.com). The ScoringSystem database allows public information on an entity to be viewed when searched using an RFID number or database assigned identification number (ScoringSystem Identification – Entity Identification; **SSI-EID**). This database was acceptable in recording and storing the appropriate information. However, the producer and consumer database interfaces were not ideally suited for easy entry and retrieval of credence attributes. Examples of credence attributes include a growing number of certifications or verifications upon which consumers may place additional value. These attributes may be certified at the farm or animal level. Examples of several of the pertinent and verifiable credence attributes to Michigan beef farms are listed in Appendix A, Table A.1. Examples of shortcomings of the ScoringSystem database, for our intended use, included tedious individual animal data entry,

data points not in alignment with our initial goals, and farm entity information available to the public only after logging into the system. The owners of the system were understandably resistant to major interface modifications, because the system works well when it is utilized as initially intended for other record-keeping purposes.

In late 2011, a series of meetings and webinars were held with Dr. J.F. Burlet, President and CEO, and representatives of Viewtrak Technologies Inc., Edmonton, Alberta, Canada. Viewtrak is a prominent industry provider of livestock information technology solutions. At our request, Viewtrak developed a proposal for assembling a database to meet the project needs, but their proposed work far exceeded the funding support within the current project.

In early 2012, a series of teleconferences were held with Dr. Mary Helander, Master Inventor and Research Relationship Manager, IBM T.J. Watson Research Center, Yorktown Heights, NY, and her colleagues at IBM. Conversations directed us toward the potential use of IBM's InfoSphere Traceability Server. This software is made available through IBM's Academic Initiative program. After several meetings, it was determined that although the use of the IBM InfoSphere Traceability Server may have been complementary to our project objectives, the information technology support needed for development far exceeded the scope of this project. In addition, there was concern that project results would not be sustainable or applicable beyond the academic environment. The principal investigators decided to proceed with the project using the ScoringAg web accessible recordkeeping system.

OBJECTIVE 3: DEVELOP A SYSTEM OF TRANSFERRING RFID EAR TAG IDENTIFICATION TO LABELS

Seventy-two (72) Angus x Simmental crossbred steers were used to evaluate a system of transferring RFID ear tag information to a carcass label. Sixty-one (61) steers were born and raised at the Upper Peninsula Research and Extension Center, Chatham, MI, and 11 steers were born and raised at the Michigan State University (MSU) Beef Cow-Calf Teaching and Research Center, East Lansing, MI. All steer calves received a RFID ear tag (Allflex USA, DFW Airport, TX) in the middle one third of their left ear while at their farm of origin. Each RFID ear tag was previously written with a 15-digit animal identification number (**AIN**). The 72 steer calves were transported from their farm of origin to the MSU Beef Cattle Teaching and Research Center, East Lansing, MI to be finished. During the finishing stage, information about each steer was recorded in an online database (ScoringSystem) and included animal breed, birth date, gender, farm of origin, and AIN. The ScoringSystem database allows viewing of public information on an entity by searching using an AIN or database-assigned identification number (SSI-EID). Steers were grouped and transported to a processing plant (Ebels Meat Processing, Falmouth, MI) during 4 successive weeks. During exsanguination, the RFID ear tag was removed from the animal and scanned using a handheld RFID reader (LightningROD Reader; I.D.ology, Eau Claire, WI). The RFID data was transmitted into barcoding software (BarTender; Automation; Seagull Scientific, Bellevue, WA) using Bluetooth data exchange to initiate the parent (harvest) label generation. As the RFID was scanned, the barcode software searched a Microsoft Excel file that cross-referenced the AIN and SSI-EID. Once exsanguinated, the carcasses were hung on a rail. The overhead rail system was a single rail, where once the carcass was hung, the order was maintained throughout the harvest process. The hot carcass weight (**HCW**) of each animal was recorded and entered into the barcoding software. Eight identical harvest labels (10.16 × 5.08 cm) were printed using a laptop computer and an industrial thermal transfer printer (model GP MAXX; Godex Americas, Camarillo, CA). The harvest label included AIN, SSI-EID, address of feedlot, premise ID number of feedlot, date, time, harvest establishment ID number, HCW of left and right halves, total HCW, and a 2D four segmented GS1 DataMatrix barcode (Figure 1). The 2D barcode contained the AIN number, SSI-EID, establishment ID, feedlot name and location, date, and time of printing. The printed labels were placed onto heavy weight manila shipping tags (12.07 × 6.03 cm). One label was placed on each carcass quarter using deadlock tag fasteners. One label was placed in a plastic bag that contained the hanging tender for

each carcass. The head, heart, and liver received the remaining three harvest labels for each carcass, but were not tracked further during this project.

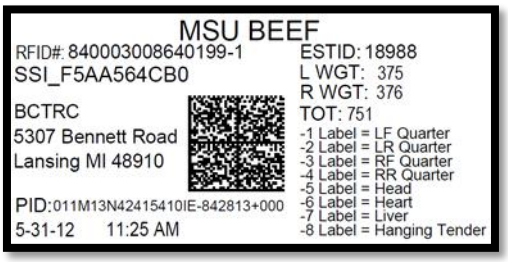

Figure 1. The harvest, parent label (10.16 × 5.08 cm) contained the animal identification number (RFID), SSI-EID, and other relevant data encoded in the 2D barcode.

OBJECTIVE 4: DEVELOP A FEASIBLE METHOD OF REPLICATING LABELS IN A SMALL- TO MID-SIZED PROCESSOR

Following harvest, carcasses were quartered and shipped to a fabricator (Byron Center Meats Inc., Byron Center, MI). Carcasses were placed in groups of nine and allotted to one of two processing and labeling methods based on their order of arrival to the fabricator. The carcass groups were processed by either serial processing method (**SER**) or parallel processing method (**PAR**). The SER consisted of one carcass (both hindquarters and forequarters) being processed before starting on the next carcass. As carcasses were processed to their final wholesale cuts, a child (in-process) label (5.08 × 2.54 cm; Figure 2) was generated for that specific carcass. Labels were generated using a mobile unit consisting of a handheld mobile scanner (model GPS SC; Intermec Technologies Corporation, Everett, WA) and a mobile printer (model P4T; Zebra Technologies, Lincolnshire, IL). A carcass specific in-process label was placed in each meat lug that contained cuts from that carcass. Each lug contained wholesale cuts from only one animal to preserve the integrity of traceability. Once full, lugs were moved to the vacuum packaging station. The PAR consisted of multiple carcasses being processed simultaneously. Ten hindquarters were processed, followed by the 10 corresponding forequarters, then 8 forequarters followed by the corresponding 8 hindquarters. During PAR, each wholesale cut was labeled individually with an in-process label (5.08 × 2.54 cm) which was created using the same method as described for SER. Identified wholesale cuts were then placed into lugs to be taken to the vacuum packaging station. The order of SER and PAR were alternated each week for 4 weeks. To create the in-process label, the 2D barcodes on harvest labels (parent labels) were scanned immediately before carcass breakdown using the handheld mobile unit. The mobile scanner recorded the information in the barcode of the harvest label, and then extracted the SSI-EID and AIN from the harvest label to be used in the in-process label. In addition, the current date and time were included in the 2D GS1 DataMatrix barcode (1.59 × 1.59 cm) on the in-process labels. Once that information was captured, the mobile software assigned a unique identity for each carcass using a 3 character alpha sequence (*i.e.*, first carcass = “AAA,” second carcass = “AAB,” and so on) followed by a serialized number indicating the number of labels printed for each carcass (*i.e.,* first label the carcass = “001”, second label for the carcass = “002”, and so on), which was also displayed as text on the printed in-process label (Figure 2). This visual serialization method was found to be cumbersome and was no longer used after the first group of carcasses. Later, each carcass was assigned a sequential number (1 to 72), which was written on the back of the in-process label for quick visual identification by the meat cutters. The handheld mobile unit was used to print six (5.08 × 2.54 cm) labels for each carcass during SER and 34 labels for each carcass for PAR. The in-process

labels were placed on a waterproof cure tags (6.99 × 3.49 cm) and then attached to the wholesale beef cuts using a plastic carcass brad (Ketchum, Brockville, ON).

Figure 2. The in-process, child label (5.08 × 2.54 cm) maintained traceability on lugs or cuts during processing. The AIN and SSI-EID were encoded in the 2D barcode.

After each lug or wholesale beef cut was identified with an in-process label, the beef cuts were moved to the vacuum packaging station. The in-process label was removed from the top-most wholesale cut of each lug for SER and each individual wholesale beef cut for PAR. Each beef cut was placed in a Cryovac (Sealed Air, Duncan, SC) bag, vacuum sealed, and then dipped into a hot water bath. Each package was dried with a towel and the in-process label for the wholesale cut was scanned with a mobile unit and the final beef package label (5.08 × 2.54 cm) was printed (Figure 3). The label was then applied to the outside of the dried package. When the in-process label was scanned, the mobile unit stored the unique 3-digit alpha character, AIN, and SSI-EID. The final package label also included the phrase "*traceback.com*", a serialized number, date, time, and a four-segmented 2D GS1 DataMatrix barcode (1.59 × 1.59 cm) that contained the Uniform Resource Locator (URL) to scoringag.com followed by the animal SSI-EID. For example, beef from an animal with an SSI-EID of 09AE16F37C would have a unique URL of www.scoringag.com/scoringag/3/Ag.cfm?sfa=main.PSA&entity_id=SSI_09AE16F37C. This URL references the web page with previously entered data for that individual animal. A schematic of the entire tracking process is shown in Figure 4.

Figure 3. The final package label contained both text and encoded AIN and SSI-EID, which allowed for searching the origin of the animal from which the product came.

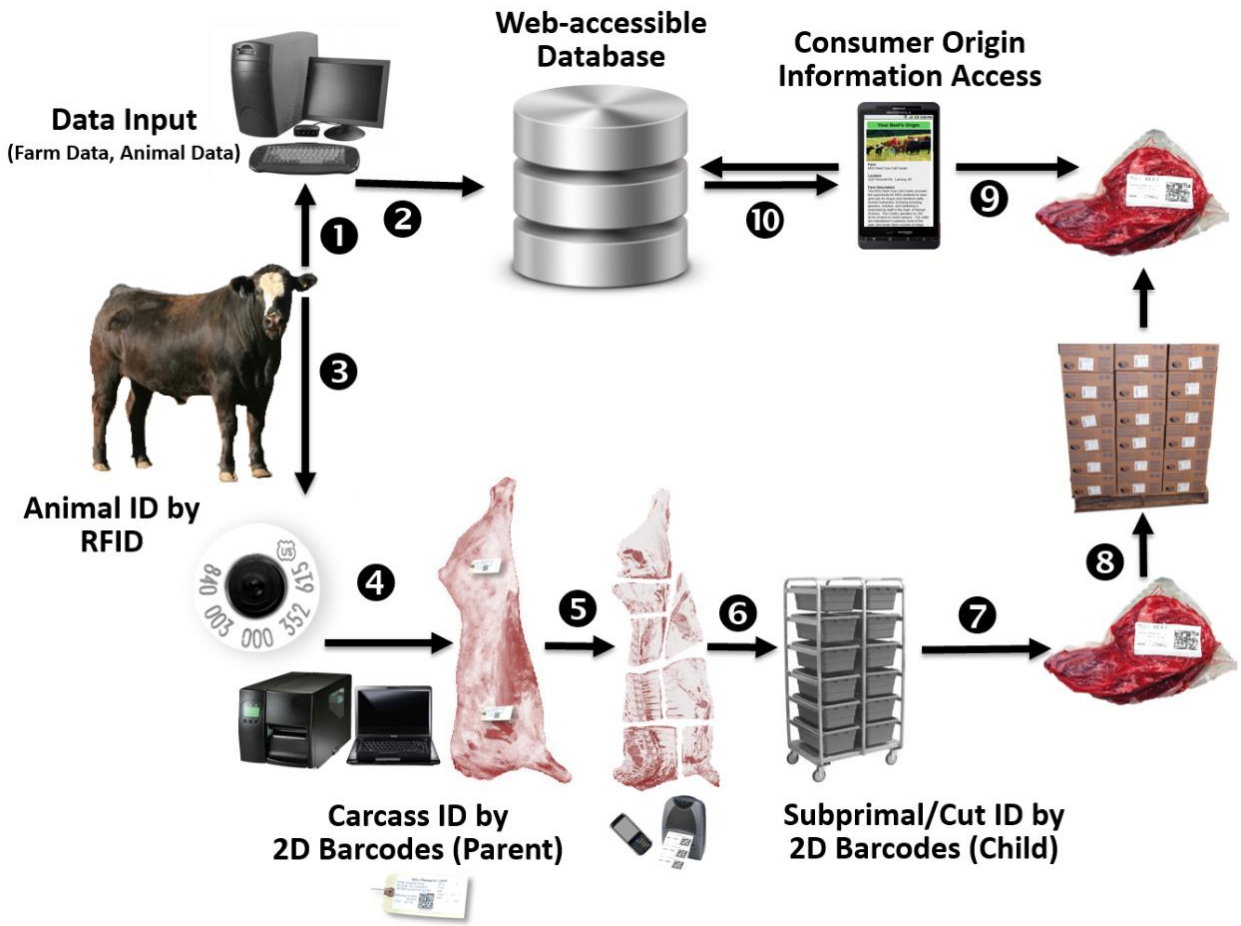

Figure 4. The unique animal identification number (AIN) carried on each animal's radio frequency identification tag and database assigned entity identification (SSI-EID) were used to maintain a unique animal record; (2) animal and farm data was added to the ScoringAg, web-accessible database; (3) at harvest, the AIN and SSI-EID were entered into labeling software; (4) label with 2D barcoded information was printed for carcass; (5) carcass was fabricated in a serial or parallel method; (6) each carcass's cuts were segregated into lugs (7) parent 2D barcode from carcass was scanned and child (in-process) labels were created and placed on lugs (serial) or subprimals/cuts (parallel); (8) subprimals/cuts were packed in boxes labeled with farm-of-origin labels; (9) 2D barcode on package can be scanned with smartphone; (10) 2D barcode calls URL address for request of publicly accessible farm and animal information from database via internet.

OBJECTIVE 5: VALIDATE THE EFFICACY OF TRACEBACK FROM BEEF PACKAGES TO INDIVIDUAL ANIMAL

Deoxyribonucleic acid (DNA) marker genotyping was used to verify the fidelity of traceability in the tested model. Using DNA genotyping of single nucleotide polymorphisms (**SNP**) is a sensitive method to definitively identify cattle (Heaton et al., 2002; Werner et al., 2004). A tissue sample of each steer was taken during the finishing stage by applying a tissue sampling ear tag. Each ear tag contained a unique 1-dimensional barcode that was then cross-referenced with the steer's AIN. The ear tag removed a punch of tissue from an ear of each animal. Following harvest and processing, wholesale cut sampling was conducted during beef thawing and preparation. Ninety-four (94) beef samples were obtained at 10 different cafeterias at MSU over nine months. Samples were collected using a meat sampling device (IdentiGEN North America, Inc., Lawrence, KS; Loftus and Meghen, 2011). The

sampling device contained a unique 1-dimensional barcode that was cross-referenced with the AIN indicated on the package tracking label. Genomic DNA was extracted from the ear and meat tissue samples and SNP genotyped using an end-point homogenous fluorescence assay system (IdentiGEN North America). Individual sample genotypes were compared for identity across all SNP tested using computer algorithms. A match was identified when the probability of 2 samples having the same genotype was 1 in > 10^6. A non-match was recorded when 2 or more allelic differences were observed.

CONTRIBUTION OF PUBLIC OR PRIVATE AGENCY PARTNERS

The work reported here is a result of multidisciplinary collaborations including public and private industry partners. The work was led by MSU personnel in the departments of Animal Science, Large Animal Clinical Sciences, and the School of Packaging. The project relied on marketing agreements and scheduling from personnel in the MSU Food Stores support services of the MSU Division of Residential and Hospitality Services. In addition, the following private industry partners were critical to the execution of the project.

ScoringSystem, Inc., Bradenton, FL – Mr. William Kanitz and Ms. Brunhilde Merker assisted in use of the ScoringAg data management system. They provided expertise on input and retrieval of data from the system.

Advanced Traceability Solutions, South Portland, ME – Mr. Donald Tomkinson created the software interface for the processing plant hand held mobile units and was the primary consultant on hardware needs for the project.

Ebels Meat Processing, Falmouth, MI – Mr. Tom and Mr. Mark Ebels allowed access to their plant and the transfer of information from animal ear tags to carcass labels.

Byron Center Meats, Byron Center, MI – Mr. Steve and Mr. Jim Sytsma allowed access to their plant and the transfer of carcass label information onto cuts and final packages.

RESULTS, CONCLUSIONS, AND LESSONS LEARNED

RESULTS

Several key results were obtained from our work, including:

An internet accessible database was used for entry and retrieval of farm and animal attributes. At the onset of this project, there were no known databases designed specifically for producers to enter animal data and the public to be able to retrieve custom fields of farm information related to that animal. Our attempts at partnering with a private entity to design a new database were met with high initial capital cost or high initial information technology personnel requirements. Use of the ScoringAg database allowed linkage of animal information to wholesale beef cuts when tied together with our tested traceability method.

A system was developed for transferring AIN and SSI-EID codes to carcass labels. Transfer of AIN to carcass labels was accomplished in a harvest plant where carcasses necessarily stayed in the same order from exsanguination until entering the cooler. A more robust tracking method would be required for plants where "*rail-outs*" may change the order of carcasses between these two points in the chain. In this project, the method of attaching labels to shipping tags, and shipping tags to carcasses using deadlock fasteners may have been more complex than

necessary. However, retention is a key factor in maintaining traceability. No tags were lost or unreadable of the 288 carcass quarters traced from harvest facility to processing facility in this project.

Labels placed on meat cuts were reproduced in a mid-sized processor. The initial plan was to print child (in-process) labels on demand, however, printing batches of labels saved on printing and labor time. The number of in-process labels used per carcass was 3.7 for SER and 30.9 for PAR. This resulted in significantly more labor required for traceability of carcasses fabricated by the PAR method. The initial serialization scheme for in-process labels was changed to a simple numbering system for easy recognition by the meat cutters. This labeling method was adequate for the number of carcasses being processed by the parallel method. Carcass brads were found to be effective at temporarily adhering labels to meat cuts. Overall, traceability costs during fabrication were estimated to be $0.03/lb of wholesale product for SER, compared to $0.07/lb for PAR. The difference in cost was primarily derived from additional labels, printer costs, and labor for the in-process portion of the parallel processing traceability method.

An important validation of meeting the project objectives was to test the agreement of product labels with the animals from which the product came. Fidelity of traceback from beef packages to individual animal was confirmed using DNA genotyping. The analysis revealed 100% traceability fidelity in the tested system. In other words, of the 94 cuts of labeled beef tested, all were correctly labeled to its animal of origin. Based on the DNA genotyping methods used, the chances of one of the cuts of beef not being from the animal as labeled would be greater than one-in-one-million.

CONCLUSIONS

Important conclusions from our work include:

Machine-readable identification in the forms of RFID and 2D barcodes provide the key features necessary in a traceability system. The methods of traceability tested in this project were logistically feasible in a small- to mid-sized harvest and processing facility.

The traceability methods employed caused little or no disruption of the routine tasks in both the harvest and processing facility. The traceability tasks completed, including transfer of RFID to labels, and label replication are tasks that plant personnel could accomplish with relatively little training.

Both methods of traceability, serial and parallel, worked as intended. Although, both methods relied on human interaction, both methods resulted in 100% accuracy in tracing product through the supply chain.

Economic returns to a traceability system will depend on both costs and returns; however, based on the modest cost of the systems tested, economic feasibility appears favorable. It appears that relatively simple traceability systems could be developed costing 1 to 2% of wholesale value.

LESSONS LEARNED

In contrast to a hypothesis by the processing facility owners, SER processing was more time efficient than PAR processing. Given that the two methods were similar in efficiency of fabricating cuts, SER is much more straightforward in applying traceability. Processing via SER appeared to provide fewer chances for traceability errors and required less labeling supplies and labor than PAR processing.

Speed of wireless communication (Bluetooth) between hand-held computers and mobile printers was found to be an important limitation in printing speed. The limitation may be a function of the mobile computer, printer, or both. This speed limitation prevented printing of on-demand labels as was initially anticipated. Printing of labels in batches was used in this project, which may not work equally as well when processing volume increases.

Use of plastic injectable meat fasteners was abandoned in favor of using plastic carcass brads. The meat fasteners, on occasion, broke upon removal leaving plastic in the beef cut. Plastic carcass brads were easy to apply and remove.

Although it was known at the onset of the project, it bears reiteration here – harvest and processing plants are harsh environments for electronics. It was particularly difficult to maintain equipment in an area of the harvest facility that was not easily sprayed with water or carcass rinses. Water resistant/proof electronic equipment is a must for operating in this environment. Similarly, processing facility operations are cooler than the desired operating temperature of many electronics, which is a hardware consideration.

There was a 4.2% (3 of 72) failure rate of ear tag samples yielding a sufficient quantity of DNA for analysis, and there was a 4.3% (4 of 94) failure rate of meat samples meeting quality standards for DNA genotyping. Sampling failures were most likely due to failure of the sampling device in the case of ear tagging, and due to failure of the sampling technique in case of the meat sampling.

BENEFITS DERIVED

This project has provided significant direct and indirect benefits including:

The most direct benefit of this project is to describe a novel way for beef (or meat) producers to add value to their products. In modern small- to mid-scale marketing scenarios, an information value chain to supply product information to consumers is often lacking. As consumers increasingly place value on credence attributes, such as food origin, creating workable traceability systems is expected to allow opportunities for product differentiation and addition of value. The additional value may be contributed, and thereby received, by any or all of the value chain participants. The implementation of traceability systems, like those described in this report, is expected to facilitate the creation of local and regional food systems.

An ancillary, yet important, benefit of the implementation of traceability systems in the U.S. is the reconnection of consumers with farmers. Over time, as consumers are further removed from farming, they are becoming more uninformed (or worse – misinformed) about production practices on modern farms. The ability to provide consumers with production information about how their food is raised, may offer long-term benefits to the agricultural community, as well as the general public. The premise of this idea is that people who have some understanding of agricultural practices are more likely to be supportive of agriculture.

This project was the impetus for an initiative to increase the supply of locally grown and processed beef for the MSU Division of Residential and Hospitality Services (MSU RHS). The MSU RHS houses approximately 15,000 residents and serves 30,000 meals daily. The participants in the supply chain include those partners listed in this report. In each of the last 2 years, this local supply chain has utilized more than 190,000 lb of live cattle to provide beef in this supply chain. The goal of this initiative is to lower the real and perceived barriers for marketing local beef at a sizeable mainstream scale by development of model templates appropriate for replication. Additionally, the initiative has provided tremendous learning experiences for undergraduate students in visualizing the entire beef supply chain.

Secondary benefits connected with this project included employment of one graduate student and three undergraduate students who gained knowledge of beef traceability and the beef supply chain. Presentations were also given by these students on the work they completed as part of this project.

FUTURE RESEARCH NEEDS

The following researchable questions are likely to advance the project goals and improve our knowledge of traceability:

Future research should examine consumer desires regarding how to receive traceability information (*e.g.*, visual label, barcode scan), when and where to receive the information (*e.g.*, when selecting product, point of sale, after purchase), and what information to receive (*e.g.*, raising and processing locations, attributes, food safety recall information). Answers to these questions are likely to be different for different demographics.

Related to the above questions, what value will various demographics place on this information? Understanding the value of information will aid in prioritization of information provided to consumers.

Different harvest and processing plant sizes and configurations will likely affect the logistics of traceability. Research on different traceability systems and their scalability is clearly warranted.

Little published information is currently available regarding the optimum barcode symbologies and sizes for the various steps in the process. Barcode readability conditions and needs are different at various points in the chain.

There is a need for a database(s) that provides easy input of data for producers and serves information easily to consumers. The design of a database should account for consumer preferences for receiving information.

BENEFICIARIES

Direct beneficiaries of this project include participants of beef supply chains, including, cow/calf producers, feedlot operators, beef harvest and processing operators, meat marketing firms, food service and retail establishments, and consumers. Value is potentially added to traceable products, because the supply chain participants are, in essence, marketing desired information in addition to their traditional product (cattle or beef).

Traceability is not necessarily scale dependent, yet smaller firms may be early adopters. The smaller the volume of animals or product, the less complex the logistical issues associated with tracing related information through the supply chain. Therefore, firms whose markets fall between large, vertically-integrated commodity markets, and direct-to-consumer markets may be among the initial benefactors of engaging in traceability systems. As an example, there are approximately 728,000 beef cow/calf operations in the U.S., and more than 90% of these operations maintain less than 100 beef cows. There are approximately 34,000 feedlot operations in the U.S., and approximately 90% of these operations market less than 500 cattle annually. These small- to mid-sized operations may have a comparative advantage in producing unique, highly differentiated products. Likewise, small- to mid-sized harvest and processing facilities may be positioned to adopt simple traceability systems utilizing RFID and 2D barcodes. This makes traceability as outlined in this project a natural fit for these firms.

Discovering viable methods and logistics to provide consumers with credence attribute information has the potential to remove a market barrier for small- to mid-sized firms. If consumers are willing to pay a premium for

the knowledge of origin and/or production information of beef, the supply chain participants involved in the system may benefit. Traceability is necessarily a cooperative effort. All of the participants in the supply chain must do their part in passing on the information or marker of that information (*i.e.* database identifier). As a result, all of the participants in the supply chain can add value by engaging in the process. Although this project was primarily focused on advancing animal origin information, addition of other production information along the chain is primarily a matter of its inclusion in the database and providing an option for retrieval.

Beef consumers may also directly benefit from this project by receiving information that they desire about their beef choices. This may be information on origin or specific credence attributes that are valuable to consumers.

Indirect beneficiaries of this project include other meat supply chains. Although there are differences among meat supply chains, many of the concepts outlined in this project are transferable to other commodities.

ADDITIONAL INFORMATION GENERATED BY THE PROJECT

Peer Reviewed Articles

Foster T. P., D. D. Buskirk, J. P. Schweihofer, D. L. Grooms, and R. H. Clarke. 2014. Application of traceability during serial or parallel beef fabrication methods. *In Preparation.*

M.S. Thesis

Foster, T. P. Beef traceability systems. M.S. Thesis. *In Preparation.*

Academic Presentations

Buskirk, D. D. 2013. Discovering value from traceability beyond ADT. U.S. Animal Health Association, Livestock ID Committee, San Diego, CA, October 22.

Foster, T. P., D. D. Buskirk, and J. P. Schweihofer. 2013. Comparison of serial and parallel beef fabrication methods in a traceable supply chain. American Dairy Science Assoc.-American Society of Animal Science Joint Annual Meeting, Indianapolis, IN, July 8-12, 2013 (Abstr.).

Tackett, S. N., T. P. Foster, and D. D. Buskirk. 2013. Development of a farm to consumer traceability model. Michigan State University Undergraduate Research and Arts Forum. E. Lansing. April 12, 2013. [*Awarded 1st place in the Agriculture, Food, & Environmental Sciences Section*].

Tackett, S. N., T. P. Foster, and D. D. Buskirk. 2013. Developing beef traceability models. Michigan State University Animal Science Undergraduate Research Forum. E. Lansing. April 5, 2013.

Foster, T. P. 2012. Traceability model for local beef supply chain. Michigan State University. Dept. of Animal Science. E. Lansing, MI, November 8.

Buskirk, D. D. 2012. RFID in the food chain: Application of auto ID in the beef industry. Automatic Identification & Data Capture Technical Institute. Ohio University, Athens. July 10, 2012.

Industry Presentations

Buskirk, D. D. 2014. Tracing cattle: Where's the beef. Precision Agriculture Action Summit 2014. Jamestown, ND. January 20.

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Television

Buskirk, D. D., 2011. MSU Food goes local. WKAR WORLD - TV Broadcast, November 16.

Radio

Issues of the environment: Tracking cattle from birth to dinner plate. July 24, 2013. Interview by David Fair, Michigan Public Radio, WEMU (89.1 FM). Available: http://wemu.org/post/issues-environment-tracking-cattle-birth-dinner-plate

Michigan tracks cattle from birth to plate. May 31, 2013. Interview by Dan Charles, National Public Radio. Available: http://www.npr.org/blogs/thesalt/2013/05/31/187327856/michigan-tracks-cattle-from-birth-to-plate

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APPENDIX A. FARM AND ANIMAL CERTIFICATIONS

Table A.1. A partial list of farm and animal certifications that may be applicable to Michigan beef production

FARM LEVEL CERTIFICATIONS		
Certification	**Certifying Organization**	**Web address**
Beef Quality Assurance Certified	National Cattlemen's Beef Association/BQA	http://www.bqa.org
MAEAP Cropping, Farmstead, and Livestock System Verified	Michigan Agriculture Environmental Assurance Program (MAEAP)	http://www.maeap.org
National Organic Program	USDA - AMS	http://www.ams.usda.gov/AMSv1.0/nop
Bovine Tuberculosis Accredited Herd	USDA - APHIS	http://www.michigan.gov/emergingdiseases
Johne's Classification	USDA - APHIS	http://vetmedce.vetmed.wisc.edu/jdvcp
AGA Grassfed Ruminant Standards	American Grassfed Association	http://www.americangrassfed.org
American Humane® Certified	American Humane Association	http://www.americanhumane.org
Animal Welfare Approved	Animal Welfare Approved	http://www.animalwelfareapproved.org
Certified Humane®	Humane Farm Animal Care	http://www.certifiedhumane.org
Food Alliance Certified	Food Alliance	http://foodalliance.org
Biodynamic Farm Standard	Demeter Association, Inc	http://www.demeter-usa.org
ANIMAL LEVEL CERTIFICATIONS		
Certification	**Certifying Organization**	
USDA Process Verified Programs[a]		
Source and Age Verified	ABS Global; AgInfoLink USA; AngusSource, American Angus Assoc.; Global Animal Management, Inc; IMI Global, Inc.; North Dakota Beef Cattle Improvement Assoc.; Red Angus Assoc.of America	
Non-Hormone Treated Cattle (NHTC)	AgInfoLink USA; IMI Global, Inc.	
Livestock Feeding Claims Audit Program	AgInfoLink USA; IMI Global, Inc.	
Minimum 50% Angus or Red Angus Genetics	AngusSource - American Angus Assoc., Red Angus Assoc. of America	
Health Program Verification	Global Animal Management Inc	
Verified Natural Beef Standard	IMI Global, Inc.	
IMI Humane Handling	IMI Global, Inc.	
USDA Grass (Forage) Fed Marketing Claim Standard	IMI Global, Inc.	
Verified Green	IMI Global, Inc.	

[a]Adapted from the official listing of approved USDA Process Verified Programs, available: http://www.ams.usda.gov

Discovering Value from Traceability Beyond ADT

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Annual Meeting
Committee on Livestock Identification
October 22, 2013
San Diego, CA

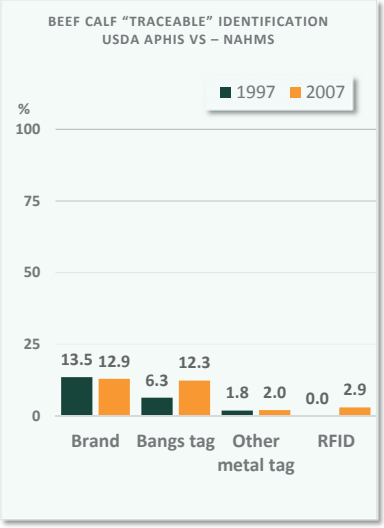
MICHIGAN STATE UNIVERSITY

Premise for this Discussion

- "The primary concerns to implementation (of ADT) are from the beef industry because of the extensive nature of that business"
  (White Paper from Join Strategy Forum on Animal Disease Traceability. Denver, CO., Aug 6-7 2013.)

- Reduction in individual, unique identification (*i.e.* brucellosis vaccination tags) has diminished our ability to trace cattle.
  (APHIS-USDA. 2004. The National Animal Identification System (NAIS): Why animal identification? Why now? What first?)

- Voluntary use of individual, unique identification would be enhanced by monetary incentive
  (Schulz and Tonsor. 2010. Cow-Calf producer preferences for voluntary traceability systems. J. Ag. Econ. 61:138-162)



There are 3 Primary Objectives for Creating Traceability Systems

Improve Supply Management

- Lower cost of distribution systems

To Facilitate Traceback

- Improve food safety and food quality
- Reduce recall impacts

ADT

Differentiate & Market Credence Attributes

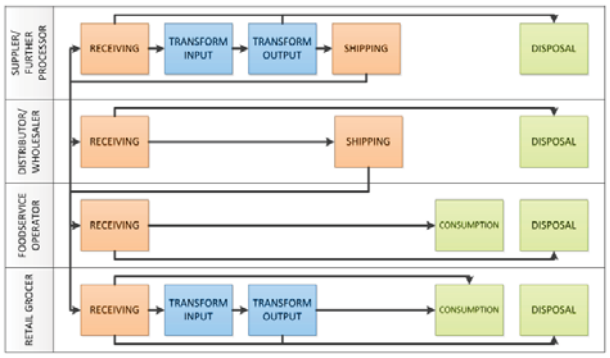
- Expand sales of products with attributes that are difficult to discern

In each case, traceability benefits equate to larger net revenues for the supply chain

Source: Golan, E., B. Krissoff, F. Kuchler, L. Calvin, K. Nelson, and G. Price. 2004. Traceability in the U.S. food supply: Economic theory and industry studies. Agricultural Economic Report Number 830, USDA ERS.

Improve Supply Management

Video: Cisco-Eagle (Excel, Dodge City, KS)



mpXML Guide for the Application of Critical Tracking Events in the Meat and Poultry Supply Chain. May 9, 2013. Available: http://www.mpxml.org

MICHIGAN STATE UNIVERSITY

Improve Supply Chain Management UHF RFID & EPCglobal Network

GS1 New Zealand

RFID Read	Business Step	EPC ID 1	EPC ID 2	RFID Reader Type	RFID Reader
1	Ear tagging	Cattle	Farm tagging station	Handheld	Tracient Padl
2	Loading cattle	Cattle	Farm race	Fixed	Intermec
3	Receiving at processor	Cattle	Processor race	Fixed	Motorola XR-450
4	Transforming	Cattle	Processor stun box	Fixed	Convergence Systems CS203
5	Storing carcasses	Carcass	Processor chiller room	Fixed	Motorola XR-450
6	Moving carcasses	Carcass	Processor boning room	Fixed	Motorola XR-450
7	Packing cartons	Cartoned meat	Processor packing line	Fixed	Motorola XR-450
8	Loading truck	Cartoned meat	Processor dock door	Handheld	Tracient Padl
9	Receiving at retailer	Cartoned meat	Retailer dock door	Handheld	Tracient Padl

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Improve Supply Management

- Assignment of individual feed disappearance

Photo: The Noble Foundation

U.S. Test Stations
- Simplot Livestock
- Circle A Angus
- Green Springs Bull Test
- Midland Bull Test
- Olsen Ranches
- Profit Maker Bulls
- Snyder Livestock
- Ridgefield Farms
- Eagle Pass Ranch
- Thorstenson Lazy TV Ranch
- Agri Research Center
- Kallion Farms
- Lucky Seven Angus
- Wardensville Bull Test, WV

Canada Test Stations
- Cattleland Feeders
- Morison Farms
- Namaka Farms

Nkrumah et al., 2006. J. Anim. Sci. 84: 145.
Herd and Arthur. 2009. J. Anim. Sci. 87:E64.

- Assignment of individual water disappearance & partial body wt.

Photo: GrowSafe

Kolath et al., 2007. Prof. Anim. Sci. 23:295
Brew et al., 2011. Livestock Sci. 140:297.

Improve Supply Management

- Recording of estrus behavior

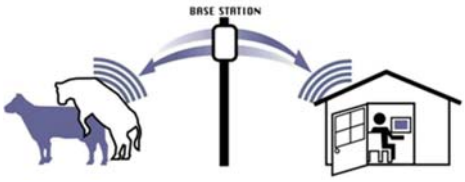


Diagram: CowChips LLC

At-Taras and Spahr, 2001. J. Dairy Sci. 84:792
Larkin et al., 2005. Reprod. Fertil. Dev. 18:289.

- Recording of rumen temperature
  - early detection of sickness, estrus, calving or heat stress

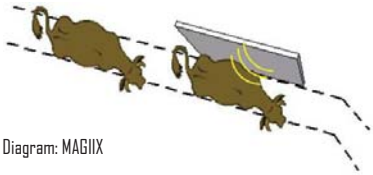


Diagram: MAGIIX

Small et al., 2008. Can. J. Anim. Sci. 88:225.
Cooper-Prado et al., 2011. J. Anim. Sci. 89:1020.

Improve Supply Management

- Recording of performance information

Photo: Michigan State University

McAllister et al., 2000. Can. J. Anim. Sci. 80:381.
Drake et al., 2009. W. Sec. Amer. Soc. Anim. Sci.

- Logistics of comingled marketing

Photo: Virginia Polytechnic Institute & State Univ.

Bolte et al., 2007. Kansas State Univ.

Improve Supply Management

- Feed bunk attendance

Photo: Michigan State University

Sowell et al., 1998. Appl. Anim. Behav. 59:275
Gibb et al., 1998. Can. J. Anim. Sci. 78:707
Schwartzkopf-Genswein, et al., 1999. Livestock Prod. Sci. 60:27

- Assignment of carcass data

Photo: U.S. Premium Beef

Paterson et al., 2005. Montana State Univ.

Improve Supply Management

- Restricting animal movement (virtual fence)

Photo: Schwage et al., 2008. J. Field Robotics

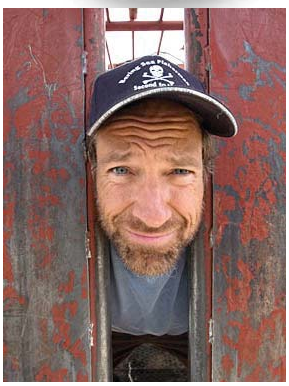
Anderson. 2007. Rangeland J. 29:65.
Umstatter. 2011. Computers Elec. Ag. 75:10.

Differentiate & Market Credence Attributes

Consumer Knowledge About How Their Food is Grown

72% of consumers "know nothing" or "very little" about farming or ranching

Source: U.S. Farmers & Ranchers Alliance Survey (n=2,417), 2011



"How is it that 300 million Americans – all addicted to eating – have become disconnected from the people who provide our food?"

-Mike Rowe,
Investigator of Dirty Jobs

Consumer Demand for "Local"

Retail: Nearly **6 in 10 Americans** are consciously **trying to buy foods that are local**
Source: American Shopper Study. 2011. BrandSpark and Better Homes & Gardens (n=63,000+ shoppers)

Food Service: Top trends
#1 Locally sourced meats & seafood
#5 Environmental sustainability
#11 Farm/Estate branded items
#198 Gazpacho
Source: What's Hot Chef Survey. 2013. National Restaurant Assoc. (n= 1,800+ chefs)

Local foods benefit from **perceptions** of both **reduced environmental impact** and **improved freshness**, as well as, consumers desire to **help local economies** and **support local farmers**.

Partial List of Farm & Animal Certifications Applicable to Beef Production (Michigan)

Certification	Certifying Organization
Farm Level Certifications	
Beef Quality Assurance Certified	National Cattlemen's Beef Association/BQA
MAEAP Cropping, Farmstead, and Livestock System Verified	Michigan Agriculture Environmental Assurance Program (MAEAP)
National Organic Program	USDA - AMS
Bovine Tuberculosis Accredited Herd	USDA - APHIS
Johne's Classification	USDA - APHIS
AGA Grassfed Ruminant Standards	American Grassfed Association
American Humane® Certified	American Humane Association
Animal Welfare Approved	Animal Welfare Approved
Certified Humane®	Humane Farm Animal Care
Food Alliance Certified	Food Alliance
Biodynamic Farm Standard	Demeter Association, Inc
Animal Level Certifications	
USDA Process Verified Programs[a]	
Source and Age Verified	ABS Global; AgInfoLink USA; AngusSource, American Angus Assoc.; Global Animal Management, Inc; IMI Global, Inc.; North Dakota Beef Cattle Improvement Assoc.; Red Angus Assoc.of America
Non-Hormone Treated Cattle (NHTC)	AgInfoLink USA; IMI Global, Inc.
Livestock Feeding Claims Audit Program	AgInfoLink USA; IMI Global, Inc.
Minimum 50% Angus or Red Angus Genetics	AngusSource - American Angus Assoc., Red Angus Assoc.of America
Health Program Verification	Global Animal Management Inc
Verified Natural Beef Standard	IMI Global, Inc.
IMI Humane Handling	IMI Global, Inc.
USDA Grass (Forage) Fed Marketing Claim Standard	IMI Global, Inc.
Verified Green	IMI Global, Inc.

[a]Adapted from the listing of approved USDA Process Verified Programs, available: http://www.ams.usda.gov

ID Events in Michigan's Bovine Tuberculosis (TB) Eradication Program

Jun 1998	1st cattle herd identified with TB, since MI obtained TB Free status in 1979
Oct 2000	Use of individual official ID mandated for all cattle movement in MI
Nov 2001	Initiated use of radio frequency identification (RFID) tags in TB tested cattle within Modified Accredited Zone
Jun 2004	RFID replaced metal tags for cattle in Modified Accredited Zone
Nov 2004	USDA-APHIS recognized 15-digit AIN as official ID
2004-05	Voluntary RFID cost-share program for producers in Upper Peninsula
Oct 2005	Upper Peninsula receives TB Free status from USDA-APHIS
Mar 2007	RFID replaced metal tag as official ID for cattle in remainder of MI

*As of **March 1, 2007**, cattle, of all ages, must be identified with an official radio frequency identification (RFID) ear tag prior to movement from a Michigan premises*

1-Dimmentional Barcode (UPC-A)

0010222013

Barcode: A symbol that encodes data into a machine readable pattern of adjacent, varying width, parallel, rectangular dark bars and pale spaces

2-Dimensional Barcode

2D barcode: symbol that contains information in both vertical and horizontal directions – contains greater volume of information than 1D barcode.

USAHA is a forum for communication and coordination among State and Federal governments, universities, industry, and other concerned groups for consideration of issues of animal health and disease control, animal welfare, food safety and public health. It is a clearinghouse for new information and methods, which may be incorporated into laws, regulations, policy, and programs. It develops solutions of animal health-related issues based on science, new information and methods, public policy, risk/benefit analysis and the ability to develop a consensus for changing laws, regulations, policies, and programs. The AAVLD promotes continuous improvement and public awareness of veterinary diagnostic laboratories by advancing the discipline of veterinary diagnostic laboratory science. The AAVLD provides avenues for education, communication, peer-reviewed publication, collaboration, outreach, and laboratory accreditation.

2D Barcodes

QR code

Maxicode

Data Matrix

PDF 417

Aztec code

Microsoft tag

"There's an App for That"

Apple

Android

Blackberry

i-nigma

ScanLife

Kaywa Reader

QuickMark

Nokia reader

Sem@code

Barcode Scanner

NeoReader

Microsoft Tag

QR code

Maxicode

Data Matrix

PDF 417

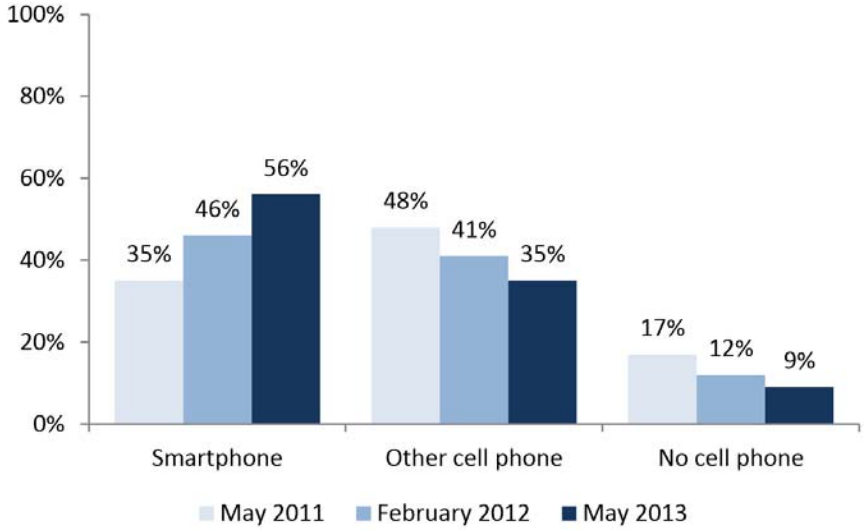
Aztec code

Microsoft tag

http://www.usaha.org/

Changes in Smartphone Ownership, 2011-13

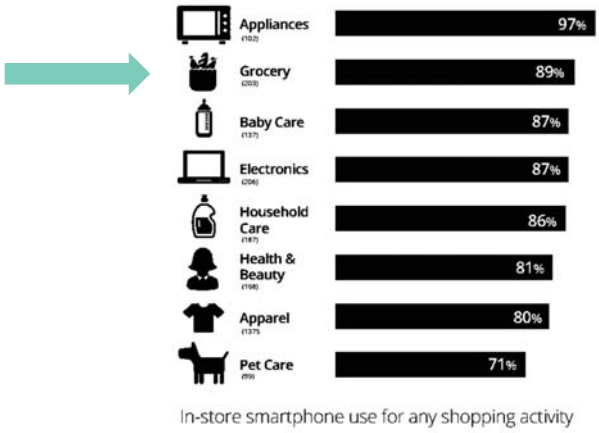
% of all U.S. adults who own…



Source: Pew Research Center's Internet & American Life Project April 26-May 22, 2011, Jan 20-Feb 19, 2012, and Apr 17-May 19, 2013 tracking surveys. For 2013 data, n=2,252 adults and survey includes 1,127 cell phone interviews.

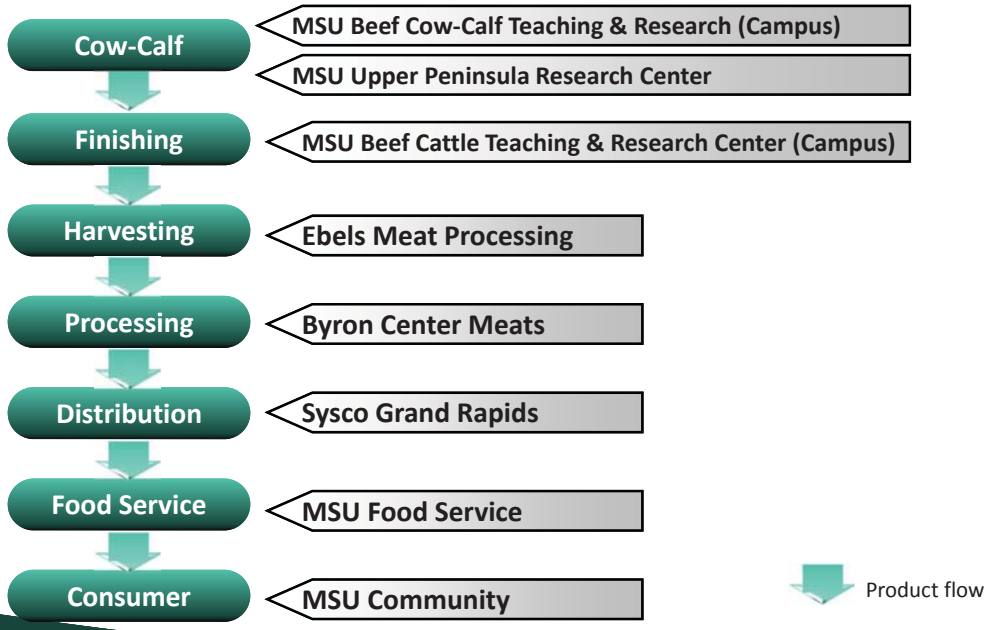
84%

of smartphone shoppers use their device to help shop while in a store



Source: Mobile In-Store Research, Google Shopper Marketing Agency Council, April 2013 Available: http://www.google.com/think/research-studies/mobile-in-store.html

MSU Local Beef Supply Chain Model



Farm-to-Consumer Traceability Model

Buskirk, D. D., J. P. Schweihofer, J. E. Rowntree, R. H. Clarke, D. L. Grooms, and T. P. Foster. 2013. A traceability model for beef product origin within a local institutional value chain. J. Ag., Food Sys. and Community Dev. 3:33–43.

AllFlex
US
840 003 000 352 615
MSU BEEF
USDA

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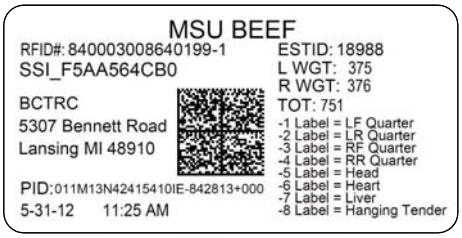
Labels

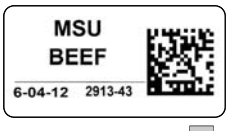
Carcass quarter label
(Traceable to animal of origin)



In-process label
(Traceable to animal of origin)

Wholesale package label
(Traceable to animal of origin)

Wholesale box & ground product label
(Traceable to farm of origin)



Serving Beef in the MSU Dining Venues

In 2011-12, 347 flyers were distributed to students receiving beef entrées. There were 55 website visits (**16%**) with individual days of distribution ranging from **4%** to **40%** visitation rate. Some visits occurred as many as **9 days** following acceptance of the flyer.

Verifying Fidelity of Tracking

Foster, T. P., D. D. Buskirk, and J. P. Schweihofer. 2013. Comparison of serial and parallel beef fabrication methods in a traceable supply chain. Amer. Dairy Sci. Assoc.-Amer. Soc. Anim. Sci. Joint Ann. Meeting, Indianapolis, IN, July 8-12 (Abstr.).

Acknowledgements

Funding:

MICHIGAN STATE UNIVERSITY | Extension

aai ANIMAL AGRICULTURE INITIATIVE

U.S. DEPARTMENT OF AGRICULTURE AMS AGRICULTURAL MARKETING SERVICE

State funds for this project were matched with Federal funds under the Federal-State Marketing Improvement Program of the AMS-USDA.

Collaborators:

Dr. Jeannine Schweihofer, MSU Extension Meat Quality Educator
Dr. Jason Rowntree & Dr. Dan Buskirk, MSU Animal Science
Dr. Dan Grooms, MSU Large Animal Clinical Sciences
Dr. Rob Clarke, MSU Packaging
Dr. Roy Black, MSU Agriculture and Food Resource Economics
Marta Mittermaier & Todd Loeffler, MSU Food Service
Chef Kurt Kwiatkowski & Sharron Frucci, MSU Culinary Services
Kevin Mahoney & Jim Hoekstra, Sysco Grand Rapids
George Quackenbush, Michigan Beef Industry Commission
Mark & Tom Ebels, Ebels Meats
Jim & Steve Sytsma, Byron Center Meats
Joe Colyn, Originz
Kevin Kirk, Michigan Dept. of Ag. & Rural Development
Donald Tompkinson, Advanced Traceability Solutions
William Kanitz, Scoring Ag

Concluding Thoughts

- While there are numerous niche traceability (or unique ID) programs, voluntary participation is still low
- To date, identification hardware availability has significantly outpaced software development – especially in the extensive beef industry
- Most consumers do not understand animal agriculture, however, there is a growing desire, at least, to know where food originates
- RFID, 2D barcodes, web database(s) & mobile devices may provide tools which will help share our story, add value, and increase participation in animal traceability

Comparison of Serial and Parallel Beef Fabrication Methods in a Traceable Supply Chain

T. Foster*[1], D. Buskirk[1], and J. Schweihofer[2],

[1]Michigan State University, East Lansing, [2]Michigan State University Extension, East Lansing.

Abstract #T174

Abstract

Traceability of meat attributes from small and mid-sized farms through supply chains is recognized as a market barrier. Automatic identification and data capture technologies such as radio frequency identification (RFID) and two-dimensional (2-D) barcodes offer the feasibility of maintaining animal and product data through carcass fabrication. The objective of this study was to determine the influence of fabrication method on beef traceability system requirements. Individual animal identity of seventy-two (72) beef carcasses were maintained during either serial or parallel processing of beef carcass quarters. Each carcass quarter was labeled with a 2-D barcode containing the animal's unique RFID ear tag number at harvest. Nine carcasses were processed on alternating days of processing by one of two methods. Carcasses were serially fabricated (SER) resulting in creation of all wholesale cuts of a single carcass before moving on to the next, or parallel fabricated (PAR) by processing 10 hindquarters followed by, 10 forequarters, 8 hindquarters, and 8 forequarters. The major difference between processing method was that beef from only one animal was on a cutting table for SER, whereas beef from multiple carcasses was on a cutting table for PAR. In-process, 5.1 x 2.5 cm "child" labels were generated by scanning the 2-D barcode on the parent carcass label with a handheld mobile computer and wirelessly printed with a mobile printer. Tracking of SER and PAR carcass quarters were accomplished by creating in-process labels for lugs and individual wholesale cuts, respectively. The amount of time required to fabricate each carcass was similar (P > 0.05) for SER (2 hours 35 minutes) and PAR (2 hours 49 minutes). The mean number of in-process labels generated per carcass for SER was 3.7 and for PAR was 30.9 (P < 0.01). The amount of time required for generating labels for SER (2 minutes 16 seconds) was less than that for PAR (8 minutes 45 seconds) (P < 0.01). Logistics of traceability was less complex for SER than PAR and did not significantly add to the time of processing beef carcasses.

Introduction

A recognized market barrier in the beef industry is the ability to track beef products, and their attributes, through the beef supply chain. By implementing the use of data capture technologies such as radio frequency identification (RFID) and two-dimensional (2-D) barcodes, product data can be maintained through carcass fabrication.

Objective

To determine the influence of fabrication method on beef traceability system requirements utilizing RFID ear tags and 2-D barcode labels.

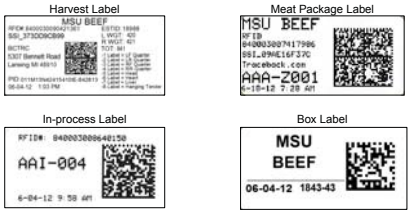
Materials and Methods

- Seventy-two (72) beef carcasses were fabricated using either serial (SER) or parallel (PAR) processing of beef carcass quarters.
- Each carcass quarter was labeled with a 2-D barcode containing the animal's unique RFID ear tag number at harvest.
- Nine carcasses were fabricated on alternating days of processing by one of the two methods.
- In-process, 5.1 x 2.5 cm "child" labels were generated by scanning the 2-D barcode on the parent carcass label with a handheld mobile computer and wirelessly printed with a mobile printer.
- Tracking of SER and PAR carcass quarters were accomplished by creating in-process labels for lugs and individual wholesale cuts, respectively.

Figure 1. Traceability Process

(1) Animal radio frequency identification (RFID) was used to maintain a unique animal record; (2) animal and farm data was added to a web-accessible database; (3) at harvest, RFID and database assigned unique number was entered into labeling software; (4) label with 2D barcoded information was printed for carcass; (5) carcass was serially fabricated; (6) each carcass' cuts were segregated into lugs within one lug-rack; (7) parent 2D barcode from carcass was scanned and child labels were created and placed on subprimals/cuts; (8) subprimals/cuts were packed in boxes labeled with farm-of-origin labels; (9) 2D barcode on package was scanned with smartphone; (10) 2D barcode called URL address for request of publicly accessible farm and animal information from database via web.

Figure 2. Label Formats



Results

- The amount of time required to fabricate each carcass was similar (P > 0.05) for SER (2 hours 35 minutes) and PAR (2 hours 49 minutes).
- The mean number of in-process labels generated per carcass for SER was 3.7 and for PAR was 30.9 (P < 0.01).
- The amount of time required for generating labels for SER (2 minutes 16 seconds) was less than that for PAR (8 minutes 45 seconds) (P < 0.01).

Table 1. Labeling of Serial vs. Parallel

	SER	PAR	SEM	P-Value
In-process labels used, number/carcass	3.7	30.9	0.2	<.0001
In-process label cost, $/carcass	$0.31	$2.63	0.02	<.0001
In-process label generation, sec/carcass	136	525	45	0.004
In-process labeling, sec/carcass	18	181	4	<.0001
Labeling labor cost, $/carcass	$0.86	$3.92	0.26	0.001

Table 2. Fabrication Economics

	SER	PAR
Fabrication labor hours, (hh:mm:ss)/carcass	2:35:23	2:50:48
Fabrication labor cost, $/carcass	$51.80	$56.93
Total cost for labeling and labor, $/carcass	$52.97	$63.48

Conclusion

Each method has merits and either or both could be used depending on the practices of the processing plant. However, based on the results of this study, if a processing plant were to chose between the two processing methods, the serial method would be more cost-efficient. Both methods allow for beef traceability that will help consumers understand where their food was raised and could potentially be beneficial in supporting local niche markets.

Acknowledgments

This project was supported in part by Michigan State University Extension. State funds for this project were matched with Federal funds under the Federal-State Marketing Improvement Program of the Agricultural Marketing Service, U.S. Department of Agriculture. The authors gratefully acknowledge the crews of the Michigan State University Beef Cow/Calf Teaching and Research Center, Upper Peninsula Research and Extension Center, and the Beef Cattle Teaching and Research Center for animal care. We gratefully acknowledge the cooperation of Ebels Meat Processing, Byron Center Meats, and MSU Residential and Hospitality Services for allowing us to work in their facilities. We are also appreciative of Donald Thomkinson , Jr., Advanced Traceability Solutions, and William Kanitz, ScoringSystem Inc., for their guidance in assembling the traceback system model. Lastly, the authors appreciate the help from Shelby Tackett for data collection and video analysis.

T174 Comparison of serial and parallel beef fabrication methods in a traceable supply chain. T. Foster*[1], D. Buskirk[1], and J. Schweihofer[2], [1]*Michigan State University, East Lansing,* [2]*Michigan State University Extension, East Lansing.*

Traceability of meat attributes from small and mid-sized farms through supply chains is recognized as a market barrier. Automatic identification and data capture technologies, such as radio frequency identification (RFID) and two-dimensional (2-D) barcodes, offer the feasibility of maintaining animal and product data through carcass fabrication. The objective of this study was to determine the influence of fabrication method on beef traceability system requirements. Individual animal identity of seventy-two (72) beef carcasses were maintained during either serial or parallel processing of carcass quarters. Each carcass quarter was labeled with a 2-D barcode containing the animal's unique RFID ear tag number at harvest. Nine carcasses were processed on alternating days of processing by one of two methods for eight days of processing. Carcasses were serially fabricated (SER) resulting in creation of all wholesale cuts of a single carcass before moving on to the next, or parallel fabricated (PAR) by processing 10 hindquarters, followed by 10 forequarters, 8 hindquarters, and 8 forequarters. The major difference between processing method was that beef from only one animal was on a cutting table for SER, whereas beef from multiple carcasses was on a cutting table for PAR. In-process, 5.1 × 2.5 cm "child" labels were generated by scanning the 2-D barcode on the parent carcass label with a handheld mobile computer and wirelessly printed with a mobile printer. Tracking of SER and PAR carcass quarters were accomplished by creating in-process labels for lugs and individual wholesale cuts, respectively. The amount of time required to fabricate each carcass was similar ($P > 0.05$) for SER (2 hours 35 minutes) and PAR (2 hours 49 minutes). The mean number of in-process labels generated per carcass for SER was 3.7 and for PAR was 30.9 ($P < 0.01$). The amount of time required for generating labels for SER (2 minutes 16 seconds) was less than that for PAR (8 minutes 45 seconds) ($P < 0.01$). Logistics of traceability was less complex for SER than PAR and did not significantly add to the time of processing beef carcasses.

Key Words: radio frequency identification, two-dimensional, beef traceability

Development of a Farm to Consumer Traceability Model

Shelby N. Tackett, Tristan P. Foster, and Daniel D. Buskirk

Department of Animal Science, Michigan State University

Introduction

The goal of this study was to research methods of beef traceability in order to meet consumers' growing demand to know where their food comes from. Ultimately, the method taking the least amount of time and resources to perform is the most useful in the beef processing industry. These models could some day allow beef products in stores to be labeled with barcodes containing animal and/or farm of origin information and will help the general public understand how their food is produced.

Materials and Methods

Seventy-two Angus and Angus x Simmental crossbred steers were used to examine alternative methods of tracking beef carcasses to wholesale cuts. Two-dimensional barcodes were used to track wholesale cuts from individual animals throughout two different processing methods. Scanning the barcode launches a mobile website that gives farm of origin information and therefore allows consumers to know the source of their selection. Video of all beef processing was digitally recorded using two digital video recorders, each equipped with two surveillance cameras for later analysis of exact timing of procedures. Carcasses were processed using a serial method one day and parallel method on the next; 9 carcasses were processed each day. The major difference between the processing methods was that beef from only one animal was available at a time on the meat cutters' tables for the serial method, whereas beef from multiple carcasses was on the meat cutters' tables for the parallel method.

Figure 1. This figure shows the overall schematic of the project from the beginning to the end. Starting with data input (1) and ending with data retrieval from the web-accessible database (10). The animal and farm of origin information are stored on the database and can be retrieved by scanning the 2D barcode with a camera-equipped mobile device. Each animal has it's own 2D barcode that follows each cut through processing.

Results

	Serial	Parallel
Average Labels Used	3.7	30.9
Total Label Cost	$2.03	$10.95
Average Labeling Time (seconds)	4.87	6.03
Average Total Processing Time per Carcass (hh:mm:ss)	0:35:31	0:45:03

Discussion

The serial method used fewer labels and a lower total label cost. The serial method also had a lower labeling time (the time it took for the meat cutter to physically reach for, grab, and insert the label into the cut of meat) as well as a lower total processing time per carcass.

Conclusion

Overall, each method has it's merits and either or both could be used depending on the practices of the processing plant. However, based on the results of this study, if a processing plant were to chose between the two processing methods, the serial method would be more cost-efficient. Both methods allow for beef traceability that will help consumers understand where their food was raised and could potentially be very beneficial in supporting local niche markets.

Additional Information on Two-Dimensional Barcodes…

There are many different types of two-dimensional (2D) barcodes that are used for many purposes. The following table describes three different types of 2D barcode by their storage capacity, printout size, and whether or not they are capable of a high-speed scan.

	QR Code	PDF417	DataMatrix
Large storage capacity	●	●	●
Small printout	●		●
High-speed scan	●		

2D barcodes can store large amounts of information by transforming it into machine-readable dots and spaces instead of the lines used in single dimension barcodes. 2D barcodes can encode URLs for websites, which makes them useful in accessing virtually any Internet location. The barcode is scanned and decoded by camera-equipped mobile devices and therefore can act as a portable database. In Japan, 2D barcodes are increasingly used as components in food traceability systems.

Acknowledgements

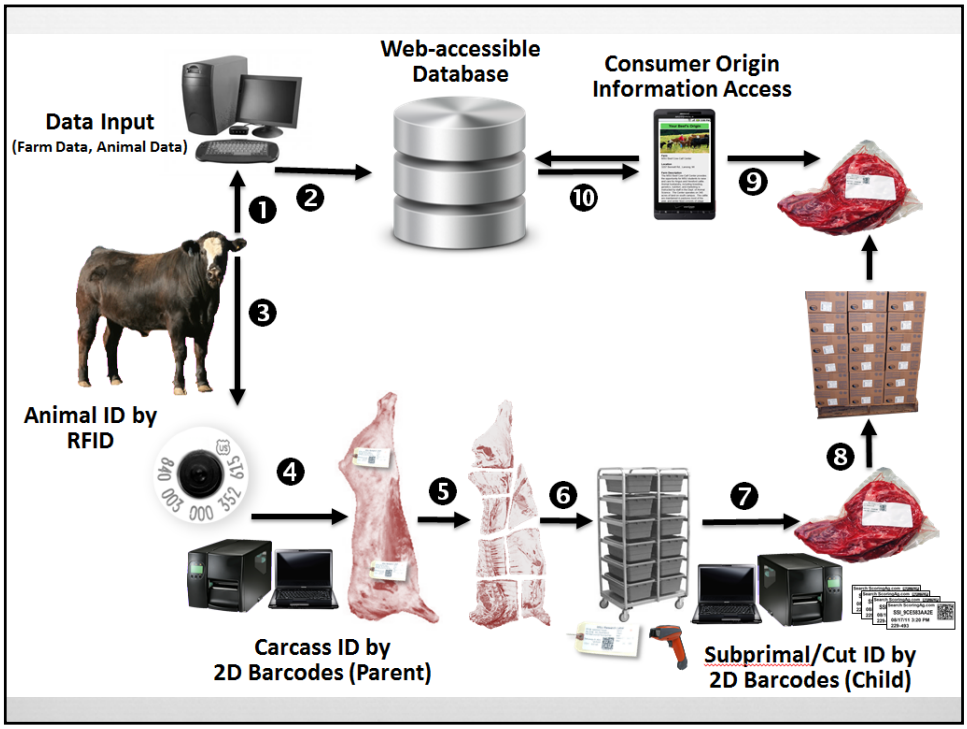
This project was supported in part by Michigan State University Extension. State funds for this project were matched with Federal funds under the Federal-State Marketing Improvement Program of the Agricultural Marketing Service, U.S. Department of Agriculture. The authors gratefully acknowledge the crews of the Michigan State University Beef Cow/Calf Teaching and Research Center, Upper Peninsula Research and Extension Center, and the Beef Cattle Teaching and Research Center for animal care. We gratefully acknowledge the cooperation of Ebels Meat Processing, Byron Center Meats, and MSU Residential and Hospitality Services for allowing us to work in their facilities. We are also appreciative of Donald Thomkinson , Jr., Advanced Traceability Solutions, and William Kanitz, ScoringSystem Inc., for their guidance in assembling the traceback system model.

Tackett, S. N., T. P. Foster, and D. D. Buskirk. 2013. Developing beef traceability models. Michigan State University Animal Science Undergraduate Research Forum. E. Lansing. April 5, 2013.

Developing Beef Traceability Models

Introduction

- The goal of this study was to research methods of beef traceability in order to meet consumers' growing demand to know where their food comes from
  - Ultimately, the method taking the least amount of time and resources to perform is most useful in the beef processing industry
- These models could some day allow beef products to be labeled with barcodes containing animal and/or farm of origin information
- Will help the general public understand how their food is produced and could help support local markets



Materials and Methods

- Seventy-two Angus and Angus x Simmental crossbred steers were used to examine alternative methods of tracking beef carcasses to wholesale cuts
- Two-dimensional barcodes were used to track wholesale cuts from individual animals throughout two different processing methods
  - Scanning the barcode launches a mobile website that gives farm of origin information and therefore allows consumers to know the source of their selection

Materials and Methods

- Video of all beef processing was digitally recorded using 2 digital video recorders, each equipped with 2 surveillance cameras for later analysis of exact timing of procedures
- Carcasses were processed using a serial method one day and parallel method on the next; 9 carcasses were processed each day
  - The major difference between the processing methods was that beef from only one animal was available at a time on the meat cutters' tables for the serial method, whereas beef from multiple carcasses was on the meat cutters' tables for the parallel method

Label used for the box to trace **farm of origin**

Label used for muscle cute to trace **animal of origin**

Results

	Serial	Parallel
Average Used Labels	3.7	30.9
Average Unused Labels	2.1	1.3
Total Label Cost	$2.03	$10.95
Average Labeling Time (seconds)	4.87	6.03
Average Total Production Time (hh:mm:ss)	4:52:15	4:41:07
Average Total Processing Time per Carcass (hh:mm:ss)	0:35:31	0:45:03

Discussion

- The serial method used fewer labels, had slightly more unused labels and a lower total label cost
- The serial method also had a lower labeling time (the time it took for the meat cutter to physically reach for, grab, and insert the label into the cut of meat)
- While the serial method took on average 11 minutes and 8 seconds longer per day, the time spent on each carcass was 9 minutes and 32 seconds less than the parallel method

Conclusion

- Overall, each method has it's merits and either or both could be used depending on the practices of the processing plant
  - Based on the results of this study, if a processing plant were to chose between the two, the serial method would be more cost-efficient
- Both methods allow for beef traceability that will help consumers understand where their food was raised
- Could potentially be very beneficial in supporting local niche markets

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Traceability Model for Local Beef Supply Chain

Tristan Foster-M.S. Student
Department of Animal Science
Michigan State University

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Overview

- Opportunities for beef traceability systems
- Current use of radio frequency identification (RIFD) in Michigan's beef industry
- MSU traceability project

Beef Industry Supply Chain

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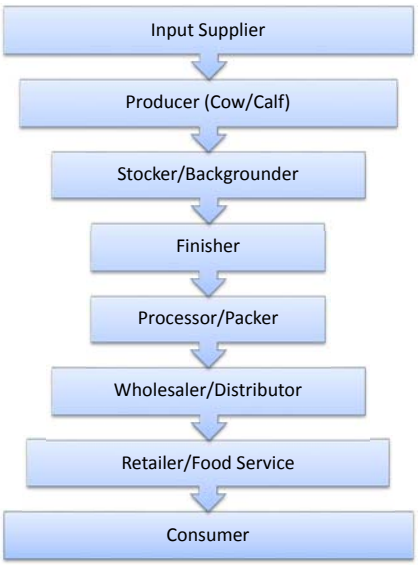

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Background Info.

- Michigan currently has a partial traceability system
- Consumer Demand
- Export Market
  - Beef and Pork (7.3% and 6.3%, South Korea 2009)
    - $1.7 billion and $518 million
- Niche Marketing
- Food Safety

Pendell, Dustin. Economic Impacts of Evolving Red Meat Export Market Access Requirements for Traceability of Livestock and Meat. 2011.

Advantages of Beef Traceability

- Decrease overall pounds for food recalls and response time
- Verifies product claims (i.e. organic, free range, etc.)
- Opens new opportunities for niche, local, and global marketing
- Increase food safety
- Potentially aid in inventory control and processing efficiency

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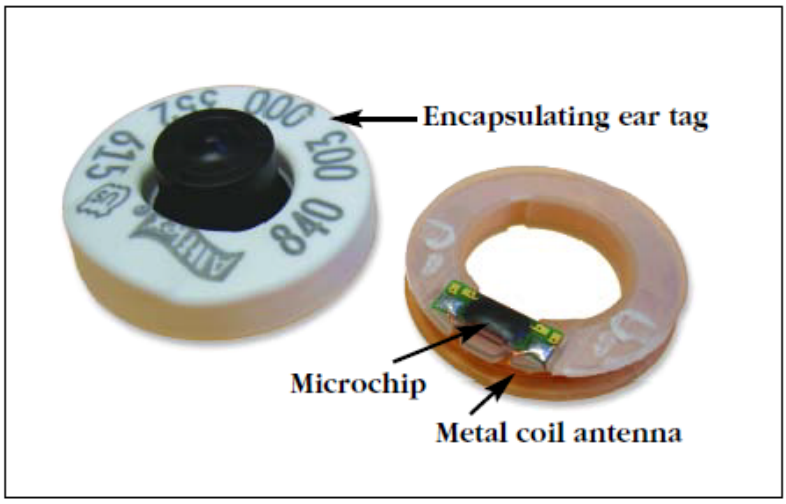
Overview

- Opportunities for beef traceability systems
- Current use of radio frequency identification (RIFD) in Michigan's beef industry
- MSU traceability project



RFID at Cow/Calf Producers

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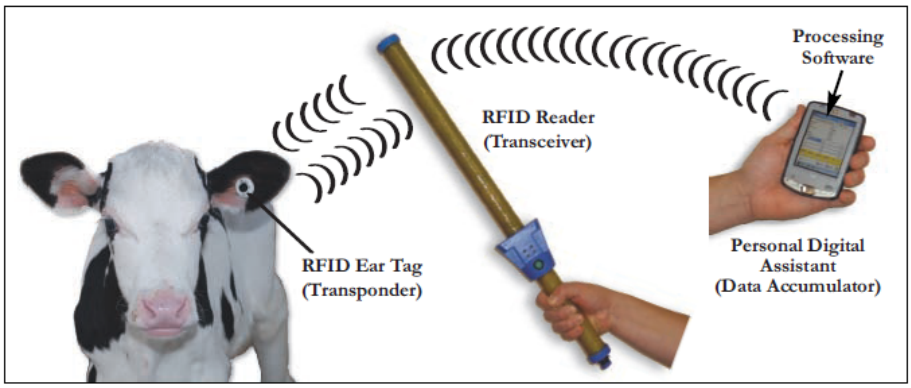
Why RFID Tags are Mandatory in MI?

- Bovine Tuberculosis
  - Effects Lymph Nodes and Respiratory Tract
  - Zoonotic Disease
- Provides for faster intra and interstate animal tracking for disease control and eradication programs
- Reduce the response time, increase accuracy, and conclusiveness to food borne diseases and to zoonotic diseases
- Allow Michigan producers to maintain and expand export markets.
- Provides assurance for pre-harvest food safety and security

RFID Scanning Process



Perceptions on RFID Tags

- Too costly to utilize the technology
- Difficult to understand
- Time Consuming

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Overview

- Opportunities for beef traceability systems
- Current use of radio frequency identification (RIFD) in Michigan's beef industry
- MSU traceability project

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Development of a Local Value Chain Model for Michigan Beef

1. Determine optimal carcass utilization for foodservice through unique carcass fabrication, culinary arts, and consumer sensory analysis
2. Develop a traceability model that extends animal identification through tracing beef cuts to the farm of origin
3. Assemble a value-added supply chain economic model that includes whole chain costs and revenues

Development of a Farm To Consumer Traceability Model

1. Create an internet accessible database for entry and retrieval of farm and animal attributes
2. Develop a user interface for producer entry and consumer retrieval of data
3. Develop a system of transferring RFID ear tag identification to labels
4. Develop a feasible method of replicating labels in a small- to mid-sized processor
5. Validate the efficacy of traceback from beef packages to individual animal

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Thesis Project Goal

"To create and compare two traceability models to be utilized in small to mid-sized processing plants that can add value to end product based on efficiency of labeling with various processing plant characteristics."

Research Hypothesis

- H_0: There is no difference in time, labor, and number of labels required between serial and parallel processing
- H_a: Serial processing will require more time, less labor, and require less labels per animal.

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Two Processes for Comparison

- Serial vs. Parallel System
  - Labor
    - Time/Cost
  - Equipment
    - Initial/Maintenance
  - Fabrication
    - Time per animal
  - Consumable Cost
  - # of labels generated

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How to track time and count labels?

- Video cameras
- Labels with a sequential unique identifier
- Measure time that the batch took to be processed and packaged
- Measure time for one animal from start to finish
- Have two printers (one at processing and one at packaging)
  - Mobile scanners and printers

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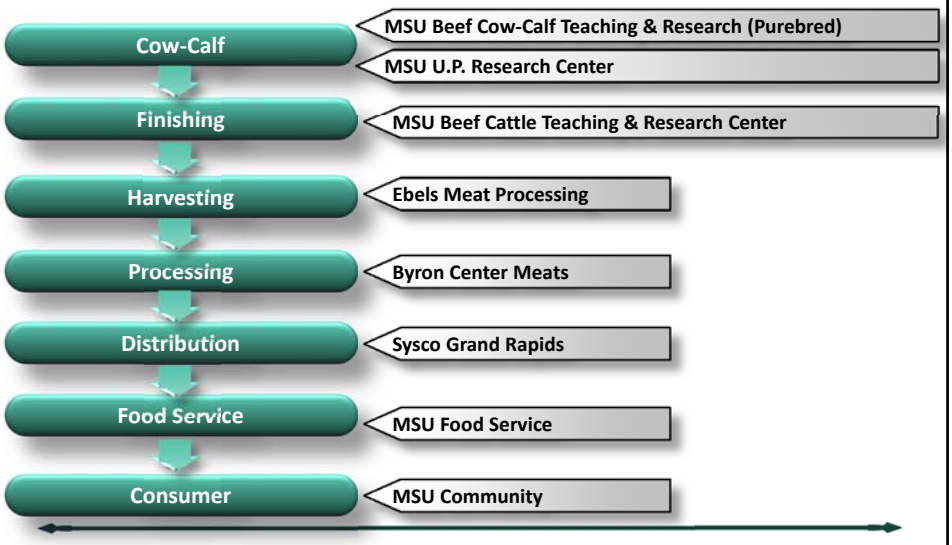
MSU Local Beef Supply Chain Model



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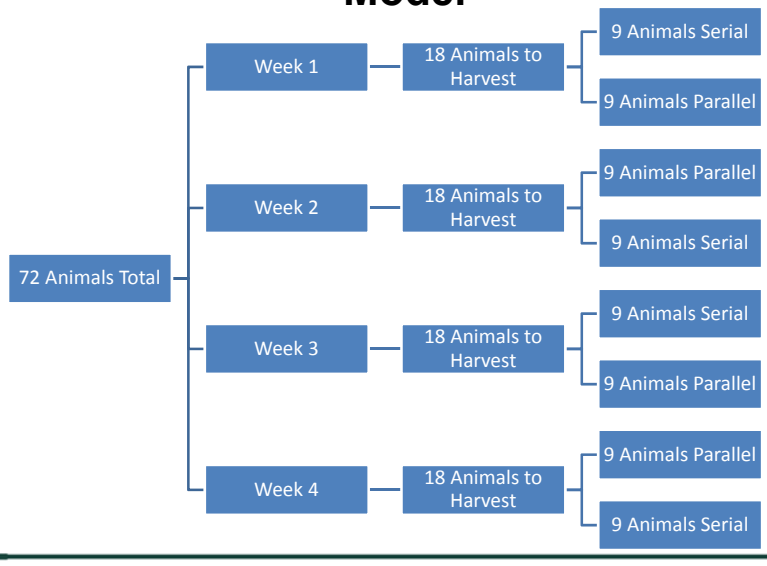
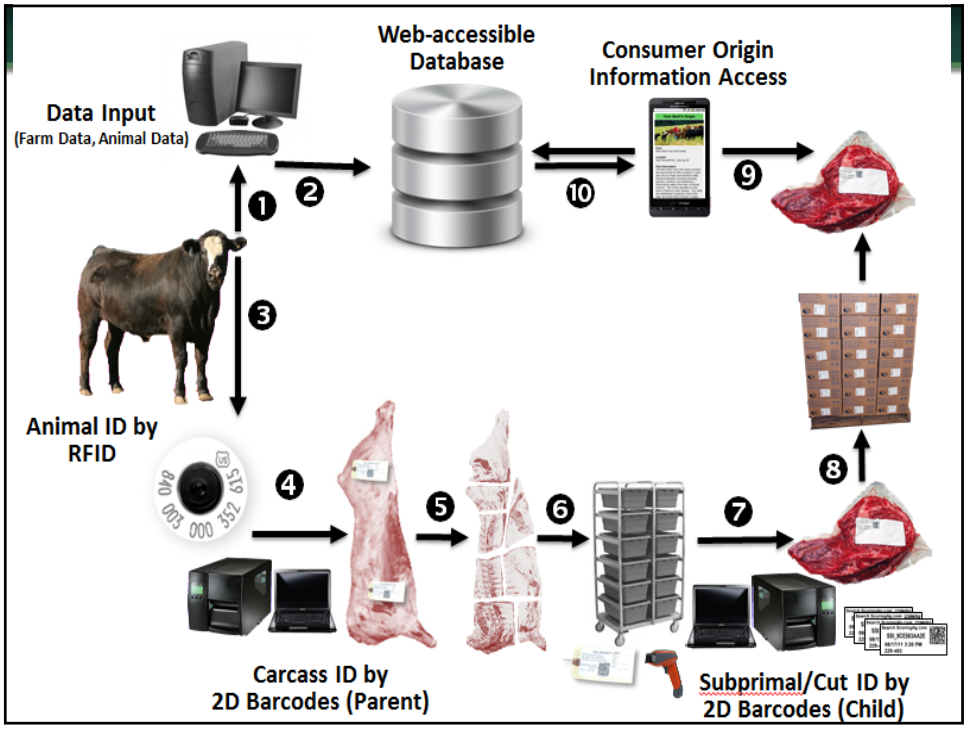
Model




Web-accessible Database
Consumer Origin Information Access
Data Input
(Farm Data, Animal Data)
Animal ID by RFID
Carcass ID by 2D Barcodes (Parent)
Subprimal/Cut ID by 2D Barcodes (Child)

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Beef Cattle Teaching & Research, E. Lansing
May 20, 2012

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Ebels, Falmouth
June 21, 2011
Dan Buskirk, Michigan State University

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Ebels, Falmouth
June 2012

2 Dimensional Codes

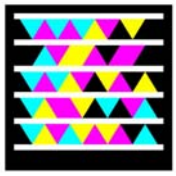
QR code

Maxicode

Data Matrix

PDF 417

Aztec code



Microsoft tag

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2 Dimensional Code

2D code: symbol that contains information in both vertical and horizontal directions – contains greater volume of information than 1D barcode.

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MSU BEEF
ESTID: 18998
RFID# 840003008640119-2
SSI_F5AA564CB0
L WGT: 442
R WGT: 451
TOT: 893
BCTRC
5307 Bennett Road
Lansing MI 48910
PID:
06-07-12 8:18 AM
Label = LF Quarter
Label = LR Quarter
Label = RR Quarter
Label = RF Quarter
Label = Head
Label = Liver
Label = Hanging Tender
18998A
U.S.D.
INSP'D&P'S'D
Ebels, Falmouth
June 2012

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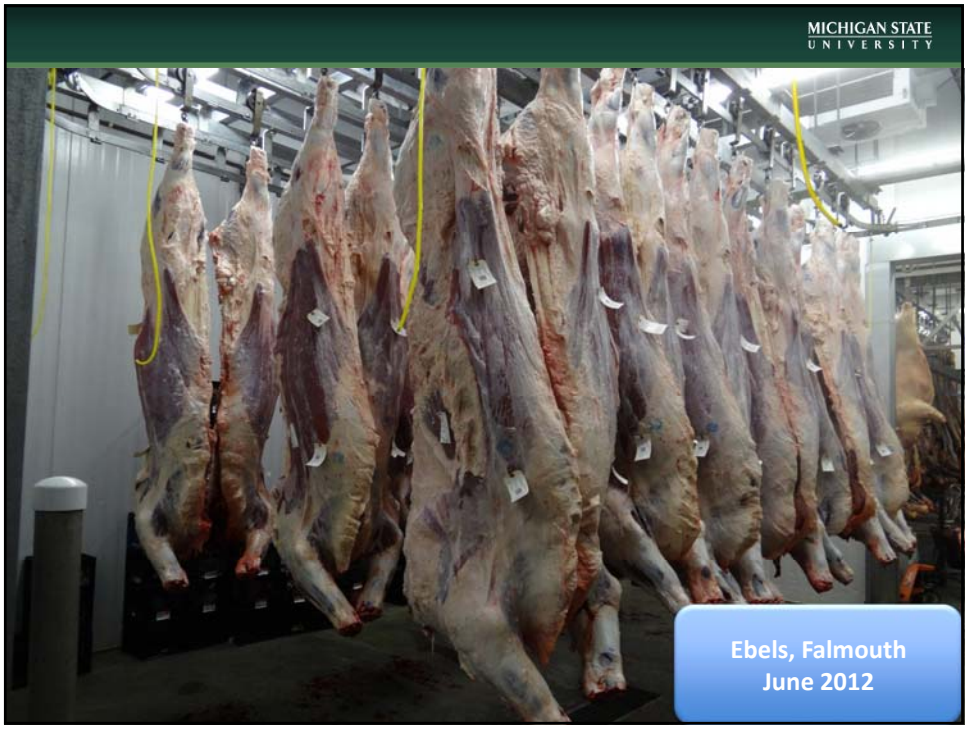
June 2012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Byron Center Meats
June 2012

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Byron Center Meats
June 2012

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Byron Center Meats
June 2012

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DNA Testing

- IdentiGEN
  - DNA Traceback
    - Ear notch samples
- Initial DNA sample collected at BCRC
- Random sample of ~140 whole muscle beef packages
  - During thawing of whole muscle cuts before preparation

RFID in the Food Chain

Application of Auto ID in the Beef Industry

Dan Buskirk, Ph.D., P.A.S., Beef Extension Specialist
Department of Animal Science
MICHIGAN STATE UNIVERSITY

Automatic Identification &
Data Capture Technical Institute
Ohio University - Athens, Ohio
July 10-15 2011

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U.S. Beef Industry Segments

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~765,000 Cow-Calf Producers ~70,000 Dairy

~50,000 Feedlot Operators

Processors

Distributors

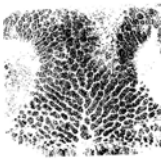
Restaurants, Hotels, Institutions, Retailers

~290,000,000 Consumers

Livestock Identification Technologies

Mechanical
- Tags, brands, tattoos

RFID
- *e.g.* tags, ruminal boluses, injectable transponders

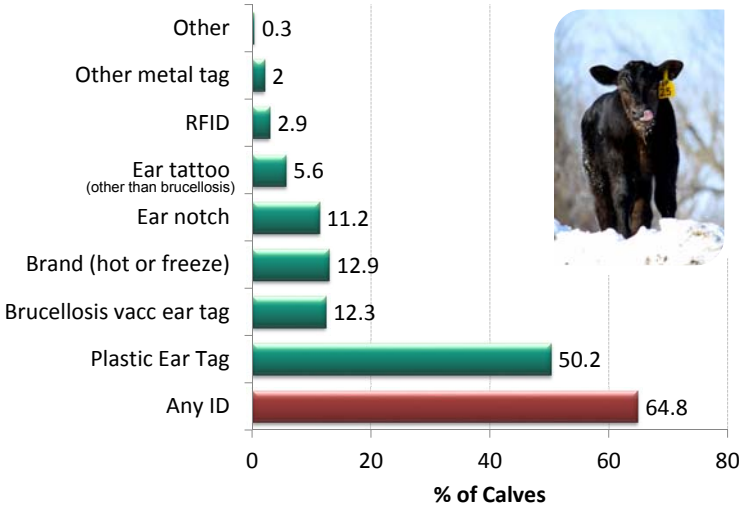


Barcoding
- *e.g.* tags

Biometric
- *e.g.* nose prints, DNA profiling, iris or retinal scans

Source: Adapted from Marchant, 2002

Forms of Calf Identification in U.S.



Source: USDA-APHIS-VS NAHMS, 2008

1
26
51
Y-Tex

Great Plains Cattle
185

RFID Physical Forms for Cattle

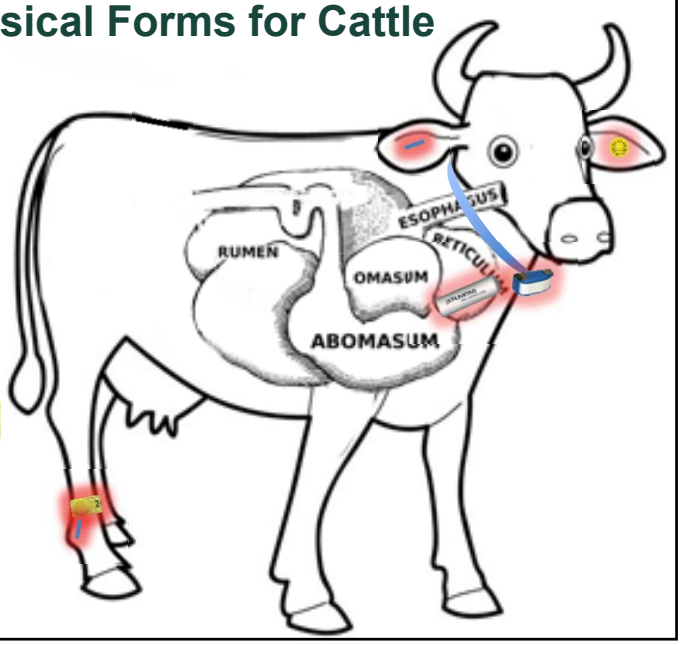
Ear Tag

Bolus

Implantable

Leg band

Neck collar



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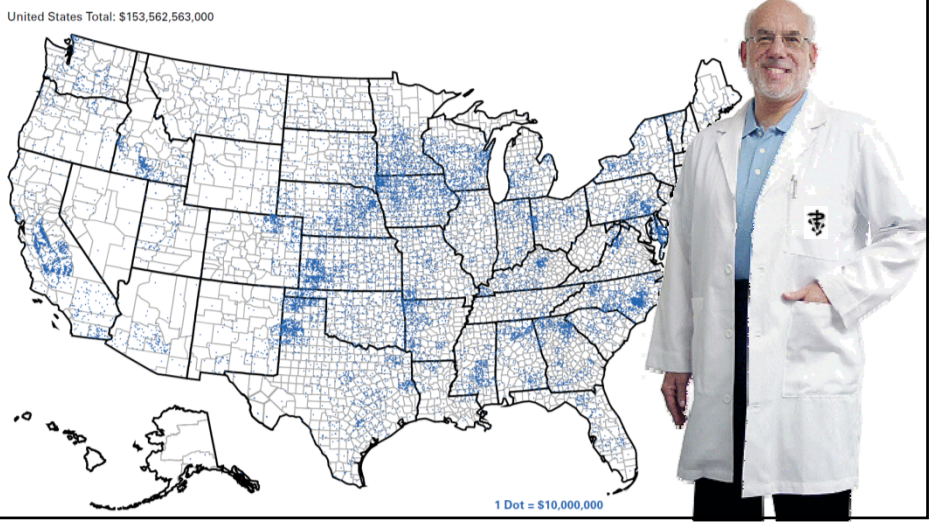
Value of livestock, poultry, and their products sold (2007)



Cattle Diseases

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Adenovirus
☹Anthrax
Aujeszky's disease
Bluetongue
Bovine anaplasmosis
Bovine babesiosis
Bovine genital campylobacteriosis
☹Bovine respiratory syncytial virus
☹Bovine spongiform encephalopathy
☹Bovine tuberculosis
Bovine viral diarrhoea
☹Brucellosis
Clostridial diseases
Corona Virus
Contagious bovine pleuropneumonia
Crimean Congo haemorrhagic fever
☹Cryptosporidiosis
☹Dermatophilosis
Echinococcosis/hydatidosis
Equine encephalomyelitis
Enzootic bovine leukosis
Epizootic haemorrhagic disease
☹Escherichia coli
Foot and mouth disease
☹Giardiasis
Haemophilus sommus
Haemorrhagic septicaemia
Heartwater
Infectious bovine rhinotracheitis
Infectious pustular vulvovaginitis
Infectious keratitis
Japanese encephalitis
☹Leptospirosis
☹Listeriosis
Lumpy skin disease
Mycoplasma bovis
New world screwworm
Old world screwworm
Parainfluenza-3
Paratuberculosis
Pasteurella (hemolytica & multocida)
☹Pseudocowpox
☹Q fever
☹Rabies
Rift Valley fever
Rinderpest
☹Ringworm
Rota virus
☹Salmonellosis
Surra (Trypanosoma evansi)
Theileriosis
Trichomonosis
Trypanosomosis
☹Vesicular stomatitis
Vibriosis

Notifiable to OIE
☹ zoonotic

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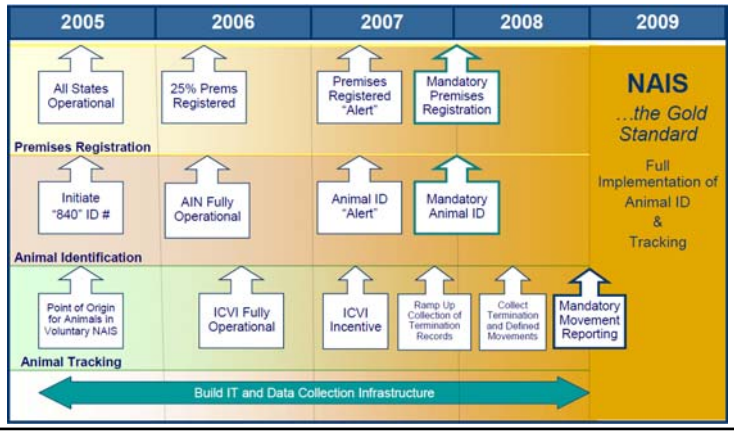
USDA-APHIS-VS
National Animal Identification System (NAIS)

Goal: Develop a traceback system that can identify all animals and premises potentially exposed to an animal with a foreign animal disease within **48 hours** after discovery.



Reasons Why NAIS Failed

- **Liability**
  - Liability maybe unfairly directed
- **Confidentiality**
  - Privacy/confidentiality of the data. Is it FOIAable?
- **Civil rights**
  - Government is over-stepping its bounds with regards to private property (land and animal)
- **Religion**
  - Objections to the "mark" and/or electronic aspect of microchip
- **Reliability**
  - Huge investment in technology – will it work?
- **Cost of system (and big vs. small)**
  - Cost would be disproportionately large for small operators

Wholesale Value of a Beef

Total $2,100.56

Source: CSU Beef Cutout Calculator, July, 2012

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Animal Traceability Becoming *Global Standard*

	Cattle population (mill head)	Premises ID	Individual Cattle ID	Group/Lot ID	Electronic ID	Animal Movement Traceability
Argentina	51.0	●	●	○	●	●
Australia	28.6	●	●	○	●	●
Canada	14.8	○	●		●	○
Uruguay	12.0	●	●	○	●	●
Brazil	207.2	◉	○	○	○	○
New Zealand	9.6	◉	○	○	○	○
Japan	4.4	●	●	○	○	●
S. Korea	2.5	●	●	○	○	●
E.U.	90.4	●	●	○	○	●
Mexico	28.6	○	○	○	○	○
U.S.	96.7	○	○	○	○	○

● = mandatory, ○ = voluntary, ◉ = mandatory/voluntary

Source: Bowling et al., 2008; Greene, 2010

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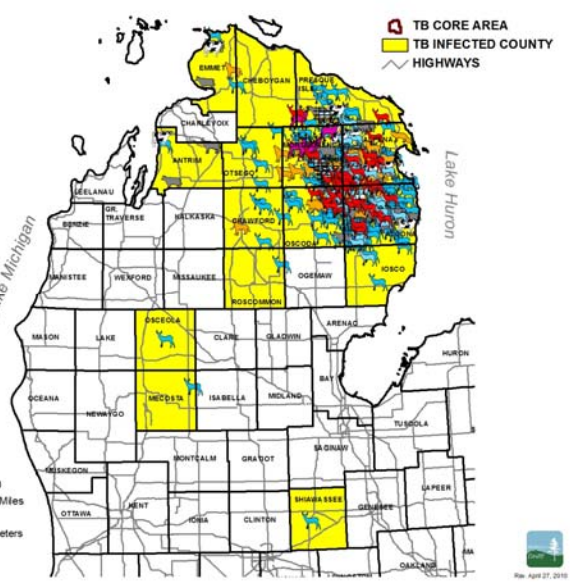
Bovine Tuberculosis (TB) in Michigan

	NUMBER
1975 TB POSITIVE DEER	1
1994 TB POSITIVE DEER	1
1995-2008 TB POSITIVE DEER	631
2009 & 2010 TB POSITIVE DEER	36
2000, 2001, 2003 & 2006 TB POSITIVE ELK	5
1996-2005 TB POSITIVE NON-CERVIDS	43
1997-2009 TB POSITIVE CAPTIVE DEER HERD	4
1998-2010 TB POSITIVE BEEF CATTLE HERDS	37*
2000-2010 TB POSITIVE DAIRY HERDS	11*
2000 TB POSITIVE CAT	1

*Includes twice infected herds



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Traceability Events in Michigan's Bovine Tuberculosis (TB) Eradication Program

Jun 1998	1st cattle herd identified with TB, since MI obtained TB Free status in 1979
Oct 2000	Use of individual official ID mandated for all cattle movement in MI
Nov 2001	Initiated use of radio frequency identification (RFID) tags in TB tested cattle within Modified Accredited Zone
Jun 2004	RFID replaced metal tags for cattle in Modified Accredited Zone
Nov 2004	USDA-APHIS recognized 15-digit AIN as official ID
2004-05	Voluntary RFID cost-share program for producers in Upper Peninsula
Oct 2005	Upper Peninsula receives TB Free status from USDA-APHIS
Mar 2007	RFID replaced metal tag as official ID for cattle in remainder of MI

*As of **March 1, 2007**, cattle, of all ages, must be identified with an official radio frequency identification (RFID) ear tag prior to movement from a Michigan premises*

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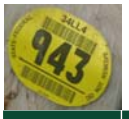
RFID Use by Animal Health Officials

- Enhance animal disease surveillance, control, and eradication
  - Furnish official identification for animals in interstate or international commerce
  - Facilitate epidemiological investigations
- Distinguish animals vaccinated and/or tested under official USDA disease control or eradication programs from unvaccinated and/or untested herdmates
- Accurately identify blood and tissue specimens used for laboratory diagnostics
- Track the health certification status of herds, States, and regions
- Enable effective regionalization and risk assessment in support of market trade

Pictured here: New Mexico Livestock Board technicians reading RFID ear tag during a routine TB test

Does RFID Traceability Save Time/Money?



	Back Tag	RFID
Tracing time, h		
Min	.03	.02
Max	70.40	.07
Mean	38.99	.04
Tracing cost, $		
Min	$1.60	$.93
Max	$194.89	$3.26
Mean	$105.80	$2.05

Source: Guta, et al., 2010

RFID Ear Tag Performance Standards

- Tag must be one-time use (tamper evident) and printing unalterable
- Tag loss rate ≤ 1% annually
- Tag life = expected animal life
- Tags must not affect health/well-being of animal nor contaminate meat or damage hide
- Tags must not discolor or deteriorate from UV light, rain, heat (45°C), cold (-30°C), chemical, mud, urine, manure for at least 5 years.
- Tags must meet ICAR testing standards for coupling/tensile strength and abrasion resistance.

Source: USDA-APHIS NAIS Program Standards and Technical Reference 2.0, 2007

USDA Official Animal Identification Number (AIN) Devices for Cattle

Low Frequency (ISO 11784/85)

Ultra High Frequency

Source: USDA, 6/12

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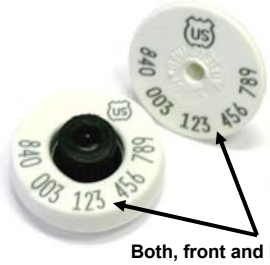
Low Frequency (134.2 kHz) RFID Ear Tags

Outside of tag



Inside of tag

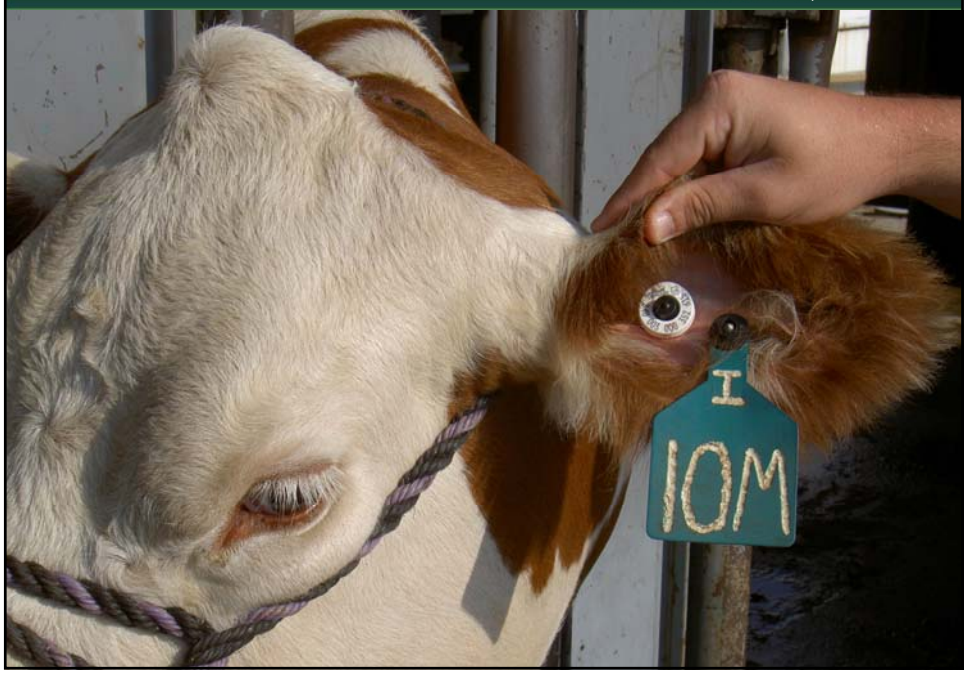
Microchip with 15-digit AIN

Coil antenna

Both, front and back of tag show unique Animal Identification Number

Country Codes
840 = USA
124 = Canada
484 = Mexico

Front and back of tags come "nested" together as a set



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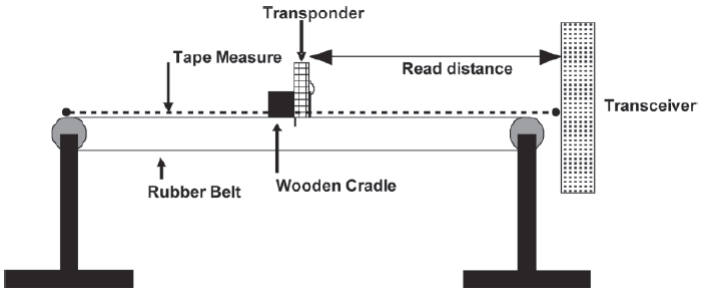
Organization for Standardization (ISO)

- ISO 11784 identifies the code structure of transponders
  - *i.e.* data code structure for animal, identification, country, manufacturer, etc.
- ISO 11785 specifies the technical concept for low-frequency transponders and transceivers used in animal ID
  - Communicate at 134.2 ± 3 kHz (ICAR, 2007)
  - Full and half duplex (*a.k.a.* FDX, HDX)
- These standards do not specify form factor, therefore apply to injectable, bolus, and ear tag transponders

Effect of Transponder Type and Transceiver Manufacturer on Read Distance

Transceiver manufacturer[2]	Transponder type[3]: Allflex FDX[4]-B	Allflex HDX[5]	Destron Fearing FDX-B	Farnam FDX-B	Temple FDX-B (EM chip)[6]	Temple FDX-B (HiTag chip)[7]	Y-Tex FDX-B
Allflex	97.1 ± 1.0^{g}	120.1 ± 1.0^{p}	94.4 ± 1.0^{gk}	87.4 ± 1.0^{j}	94.4 ± 1.3^{gk}	105.2 ± 1.6^{i}	67.7 ± 1.0^{d}
Boontech	113.7 ± 1.0^{m}	119.9 ± 1.1^{n}	104.4 ± 1.0^{l}	123.1 ± 1.0^{o}	129.9 ± 1.3^{p}	122.7 ± 1.6^{no}	94.7 ± 1.0^{gk}
Destron Fearing	68.1 ± 1.1^{d}	77.2 ± 1.1^{fg}	67.6 ± 1.1^{d}	56.5 ± 1.1^{b}	68.9 ± 1.4^{de}	72.7 ± 1.8^{ef}	45.6 ± 1.1^{a}
Farnam	81.1 ± 1.0^{h}	76.2 ± 1.0^{f}	75.0 ± 1.0^{f}	92.7 ± 1.0^{j}	97.1 ± 1.3^{g}	87.2 ± 1.6^{i}	71.2 ± 1.0^{e}
Osborne	79.7 ± 1.0^{gh}	103.2 ± 1.0^{l}	74.9 ± 1.0^{f}	80.1 ± 1.0^{h}	85.0 ± 1.3^{i}	87.8 ± 1.6^{i}	61.3 ± 1.0^{c}

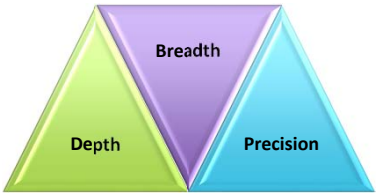
[a-p]Means within table array lacking a common superscript letter differ ($P < 0.05$).
[1]Read distance (cm) ± SEM; transponder type × transceiver manufacturer interaction ($P < 0.0001$).
[2]n = 5 for Allflex (Allflex USA, Dallas, TX), Boontech (Boontech Pty Ltd., Kyneton, Victoria, Australia), Farnam (Farnam Companies Inc., Phoenix, AZ), and Osborne (Osborne Industries Inc., Osborne, KS) transceivers, n = 4 for Destron Fearing transceivers.



Source: Ryan et al., 2010 J. Anim. Sci. 88:2514

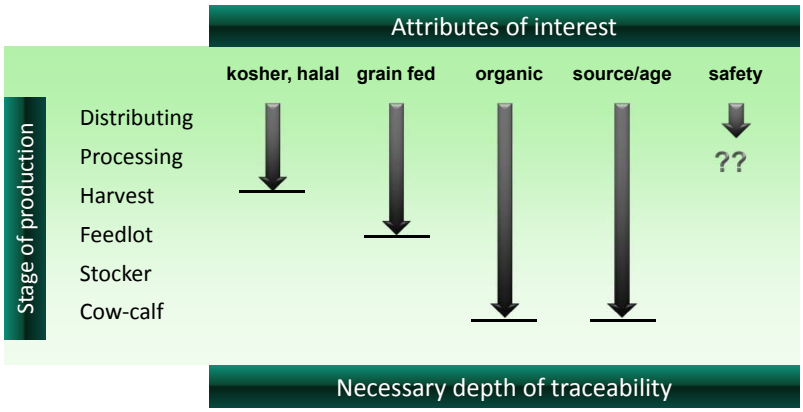
Objectives for Traceability Systems in Food Industry

- Improve supply management
  And in the case of animals, management of the supply…
- Facilitate traceback for food safety & quality
- Differentiate and market foods with subtle or undetectable quality attributes



Source: Golan, et al., 2004 (USDA-ERS)

Traceability System - Depth



Source: Adapted from Golan, et al., 2004

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Performance Data Collection

Performance data can be entered into electronic databases along with RFID

Photo courtesy J. Lindquist, MSUE

Pictured here: Michigan cow/calf producer entering animal data into a PDA at weaning processing

Performance Data Collection

Performance data can be entered into electronic databases along with RFID. This is especially useful when combining previous history with current data.

Pictured here: Working bulls at the MCA/MSU Performance Bull Test

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Performance Data Collection

Performance data can be entered into electronic databases along with RFID. This is especially useful when combining previous history with current data.

Sequencing station	Video imaging	Weigh station	Ultrasound station	Processing chute

Pictured here: Accu-Trac® ECM Process at Decatur County Feed Yard, Inc., Oberlin , KS

Comingling Logistics

Cattle can be comingled at feedyards or livestock markets and managed by RFID number

Photos courtesy S. Griener, VPI

Pictured here: Working "Mid-Atlantic VQA" feeder calves at Lynchburg Livestock Market, Lynchburg, VA

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Carcass Data Collection

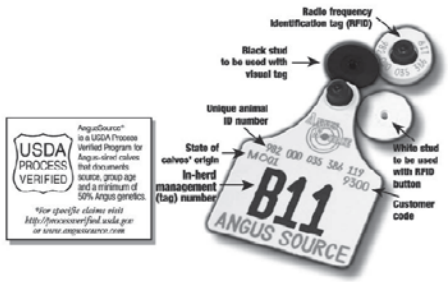
Cross-linking RFID and plant ID numbers aids in individual carcass data reporting

Photo courtesy US Premium Beef

Pictured here: RFID's of cattle entering U.S. Premium Beef facility are read. USPB returns individual (by RFID) carcass data via spreadsheet to cooperators.

Unique ID for Process Verification

Processes can only be verified if cattle can be assuredly and uniquely identified (*i.e.* USDA PVP)



Pictured here: Calf enrolled in the Angus Source® program, with verified age, source, and genetics.

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USDA Process Verified Program

USDA PVP uses ISO 9000 standards for documented quality management systems as a format for evaluating program documentation to ensure consistent auditing practices and promote international recognition of audit results.

Examples of USDA PVPs

- ***Source & age***
- ***Minimum % of breed genetics***
- ***Non hormone treated cattle (NHTC)***
- ***No animal proteins fed***
- ***Grass fed***
- ***Animals not confined***
- ***Pesticide free***
- ***Animal welfare management system***
- ***Documented health history***
- ***Fed corn for 100 days***
- ***Vitamin E fed (500 IU/day)***
- ***Carcass specifications***
- ***Truck drivers certified***
- ***Not fed human food waste or animal waste products***
- ***Never Ever 3 (No antibiotics, growth promotants, or animal by-products)***

USDA PROCESS VERIFIED

Source: www.ams.usda.gov/lsg/arc/audit.htm

Identify Animals at a Location

RFID systems can be used to identify when a given animal is occupying a particular space

Photo courtesy Univ. of Illinois

Pictured here: University of Illinois researchers are using the GrowSafe system to measure individual intakes and eating behavior.

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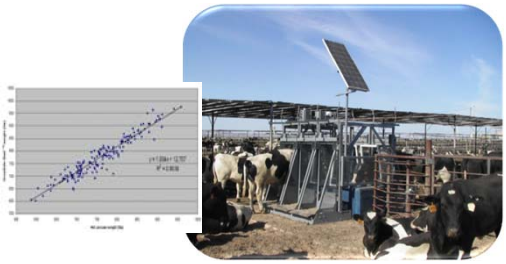
Other Applications

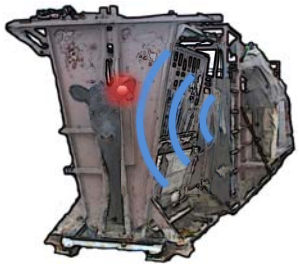
RFID systems will be used to intermittently or continuously monitor cattle performance and health



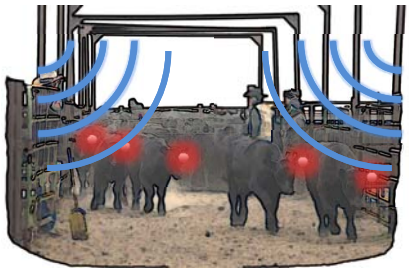
Pictured here: TekVet™ system continuously monitors tympanic temperature. GrowSafe Beef™ system monitors weight while cattle are drinking.

Different Frequencies - Different Applications

Low Frequency Application



Ultra High Frequency Application



Ultra High Frequency (~915 MHz) RFID Ear Tags

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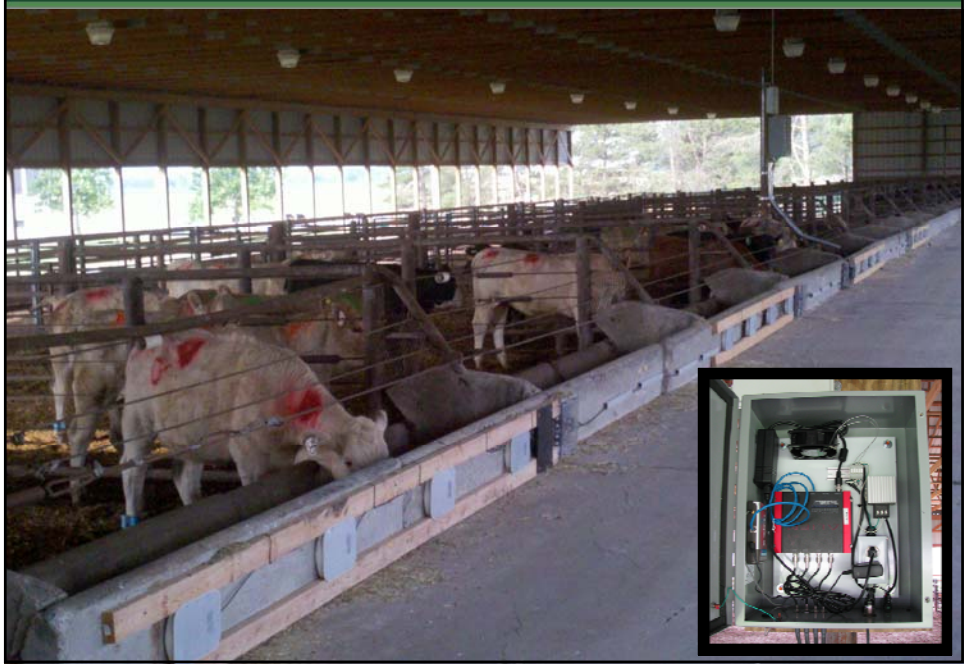

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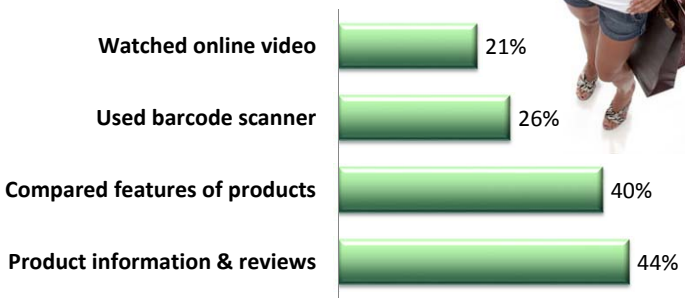
79% of Users Rely on Smartphones to Help with Shopping



Source: The Mobile Movement Study, Google/Ipsos OTX MediaCT, Apr 2011

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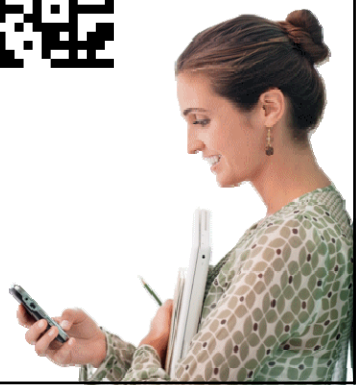

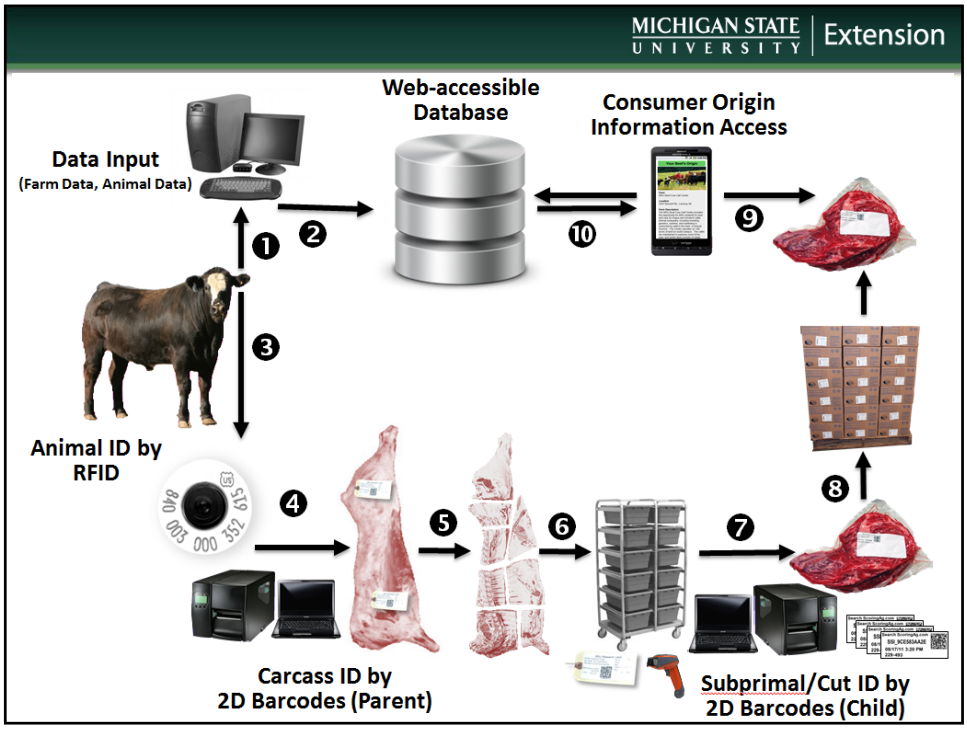
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Web-accessible Database
Consumer Origin Information Access
Data Input
(Farm Data, Animal Data)
Animal ID by RFID
Carcass ID by 2D Barcodes (Parent)
Subprimal/Cut ID by 2D Barcodes (Child)

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08/17/11 2:50 PM
229 - 194

boxes and ground product packages
[**Traceability to farm-of origin**]

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muscle cuts
[**Traceability to animal-of origin**]

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"The greatest software packages, the greatest tags, the greatest technology out there is useless, unless we have people who want to work together with the same vision and commitment to make it happen."

Chuck Fries,
AzTx Cattle Company

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