Available online at www.sciencedirect.com
SCIENCE DIRECT®
Meat Science 71 (2005) 174–193
MEAT SCIENCE
www.elsevier.com/locate/meatsci

Review

Traceability from a US perspective

G.C. Smith *, J.D. Tatum, K.E. Belk, J.A. Scanga, T. Grandin, J.N. Sofos

Center for Red Meat Safety, 1171 Campus Delivery, Colorado State University, Fort Collins, CO 80523-1171, USA

Abstract

Traceability of a food consists of development of "an information trail that follows the food product's physical trail". Internationally, the US is lagging behind many countries in developing traceability systems for food in general and especially for livestock, poultry and their products. The US food industry is developing, implementing and maintaining traceability systems designed to improve food supply management, facilitate traceback for food safety and quality, and differentiate and market foods with subtle or undetectable quality attributes. Traceability, for livestock, poultry and meat, in its broadest context, can, could, or will eventually be used: (1) to ascertain origin and ownership, and to deter theft and misrepresentation, of animals and meat; (2) for surveillance, control and eradication of foreign animal diseases; (3) for biosecurity protection of the national livestock population; (4) for compliance with requirements of international customers; (5) for compliance with country-of-origin labeling requirements; (6) for improvement of supply-side management, distribution/delivery systems and inventory controls; (7) to facilitate value-based marketing; (8) to facilitate value-added marketing; (9) to isolate the source and extent of quality-control and food-safety problems; and (10) to minimize product recalls and make crisis management protocols more effective. Domestically and internationally, it has now become essential that producers, packers, processors, wholesalers, exporters and retailers assure that livestock, poultry and meat are identified, that record-keeping assures traceability through all or parts of the complete life-cycle, and that, in some cases, the source, the production-practices and/or the process of generating final products, can be verified. At issue, as the US develops traceback capabilities, will be the breadth, depth and precision of its specific traceability systems.

Keywords: Animal identification; Animal traceability; Livestock; Poultry; Meat

Contents

* Corresponding author. Tel.: +1 970 491 5226; fax: +1 970 491 0278.
E-mail address: gsmith@agsci.colostate.edu (G.C. Smith).

0309-1740/$ - see front matter
doi:10.1016/j.meatsci.2005.04.002

1. Introduction

Food traceability is in the news; recent news stories have focused on tracking cattle from birth to finished product to control the risk of Mad Cow Disease, on tracking food shipments to reduce the risk of tampering, and on traceability systems to detail country of origin, animal welfare and genetic composition (Golan, Krissoff, & Kuchler, 2005). Sparks (2002) reported that heightened awareness of food-related safety issues among today's food consumers, coupled with a more educated public, is driving the demand for more information about the vertical food supply chain and specifically, the origin and handling of the basic commodities and food products generated and consumed throughout the world. Recent animal health and foodborne illness scares in all parts of the globe are creating a demand for source verification, food safety and supply chain identification of food products (Sparks, 2002). Golan et al. (2004) concluded that US private-sector food firms are developing, implementing and maintaining substantial traceability systems designed to (a) improve food supply management, (b) facilitate traceback for food safety and quality, and (c) differentiate and market foods with subtle or undetectable quality attributes. Despite that, and even though the US has typically set the operating standard for international food handling, the US food industry may be lagging regarding traceability; there is currently not a standard process that identifies a traceable product, nor is a brand or social equity of a traceable product currently established in many of the end-user markets (Sparks, 2002). Nortje (2002) reported that consumers in Europe, Japan, the US, and elsewhere are concerned about what is happening to their food supply, where is it from, how was it produced and, most importantly of all, is it safe. According to some industry analysts, every company connected with the world's food supply chain will eventually have to embrace traceability or find it difficult to stay in business; the facts are uncompromising, and pressure continues to mount from consumers, the media, retailers and numerous government regulatory agencies (Gledhill, 2002).

2. Traceability in the US food industry

Firms build traceability systems to improve supply-side management and construct lower-cost distribution systems, but simply knowing where a product is in the supply chain does not improve supply management unless the traceability system is paired with a real-time delivery system or some inventory-control system (Golan et al., 2004). An indispensable element of any supply management strategy is the collection of information on each product from production to delivery or point-of-sale; the idea is "to have an information trail that follows the product's physical trail" (Simchi-Levi, Kaminsky, & Simchi-Levi, 2003). Throughout the food industry, companies are adopting new electronic traceability systems ("information trails") to track production, purchases, inventory and sales to provide a basis for good supply management, allowing them to more efficiently manage resources. In 2003, Wal-Mart, the largest volume food retailer in the US and the most notable meat customer to require traceback, served notice that it expected its top 100 suppliers to be shipping goods to it with a new radio-tagging technology [Radio Frequency Identification (RFID)] by January 1, 2005. It appeared in late 2004 that a minority of those suppliers would make the deadline because traceback and tracking are expensive, complicated and difficult to manage (Feder, 2004; Food Production Daily, 2004; Fordice, 2004). However, Neff (2005) reported that (1) they may not have been eager and the technology may still have some kinks, but almost all (98 of 100) of Wal-Mart's top 100 suppliers are participating in the giant retailer's first rollout of RFID in Texas in January 2005. (2) And, while payback for participation may be years ahead, or even never come at all, for many food companies, few if any can afford to ignore RFID. (3) Not only is Wal-Mart testing RFID in the Dallas area, but rivals Target and Albertson's are piggybacking on the Wal-Mart effort by rolling out their own tests there. (4) More broadly, the US Department of Defense, European retailers Tesco and Metro and at least two more major retailers are preparing their own RFID rollouts. Neff

(2005) reported that, so far, Unilever has complied with the Wal-Mart mandate by adopting the relatively easy "slap and ship" capability (in which RFID tags are applied post-production in distribution centers, rather than during production) but will use "generation two" tag technology and convert to the new global-standard tag technology in 2005.

Traceability systems help firms isolate the source and extent of safety or quality-control problems and have an incentive to invest in traceability systems because they help minimize the production and distribution of unsafe or poor quality products, which in turn minimizes the potential for bad publicity, liability and recalls (Golan et al., 2004). The advent of the use of discount cards for supermarket customers, to track sales, enhances the potential to target recalls, allowing, for example, use of such data to identify and warn customers who had purchased suspect meat after the discovery of the first BSE case in the US (Anderson, 2004). Gledhill (2002) says meat processors can minimize risk by proactively adopting more stringent standards relative to "life-cycle traceability" of their products; such traceback offers a strategic advantage that can greatly reduce costs in the event of a product recall and reinforce the confidence of customers and consumers in the strength and integrity of a company's products and brands. Domestic and export customers, to protect their investment in "own brands", are demanding that their suppliers traceback food products to source-of-origin.

The events of September 11, 2001 in the US caused Congress to recognize that the safety of our nation's food supply could be compromised easily by a bioterrorist attack; in response, the US Congress passed, and President Bush signed into law (June 12, 2002), the Public Health Security and Bioterrorism Preparedness and Response Act (Shapiro, 2002). Under that law, the FDA has authority to order the detention of any food, if as determined during an inspection, examination or investigation, there exists "credible evidence or information" indicating that the article "presents a threat of serious adverse health consequences or death to humans or animals" (Shapiro, 2002). Fordice (2004) says big-volume food buyers like RFID because the technology improves management of the supply chain and, in the case of the US Department of Defense, creates an identification trail for the Department of Homeland Security to follow, if need be. Clearly, states Fordice (2004), tracking and traceback will be "givens" in the retail, foodservice and export arenas in the near future.

Jenkins (2003) states (a) focus on bioterrorism, genetically modified organisms (GMOs), country-of-origin labeling (COOL), biofarming, overall food safety and pending legislation to monitor the industry has created a more informed consumer base, which contributes to a shift in global food supply networks and (b) consumers exert pressure on farmers, food processors and manufacturers because of concerns about overall safety and genetic heritage of the groceries they put into their cupboards. Food producers differentiate products over a wide variety of quality attributes (e.g., taste, texture, nutritional content, origin); consumers can easily detect some attributes (e.g., color) but other innovations involve "credence attributes" – i.e., characteristics that consumers cannot discern even after consuming the product (Darby & Karni, 1973). Credence attributes are defined by Golan et al. (2004) as (a) content attributes: these affect the physical properties of a product (e.g., amount of calcium in enriched orange juice) or (b) process attributes: these do not affect final product content but refer to characteristics of the production process (e.g., country-of-origin, free-range, earth-friendly). Identification and traceability are essential for marketing food products; and, if food products are being differentiated via content and/or process credence attributes, record-keeping, auditing and validation are essential elements of verification for "identity preservation" and "authenticity management".

Nortje (2002) said food safety concerns (e.g., BSE, FMD, TB) in Europe, Japan, Canada, the US and other communities, and the associated trade complications had, and are having, a profound impact on the way domestic food-animals are identified and the purposes for which such identification is used; this enhanced interest from the consumer side, and the consequences and risks of associated litigation, moved animal identification programs from live animal identification for animal disease-tracking…to a position where such programs are expected to be an integral part of comprehensive, full-supply-chain traceability systems.

3. Definitions of identification, traceability and verification as the terms are used in the US

Confusion exists, in both the public and private sectors of the US, regarding use of the terms "identification", "traceability" and "verification". It is easy to identify, very difficult to accomplish traceability, and even more difficult to verify identity, traceability and claims about livestock and meat. As an analogy, we identify automobiles by hanging license tags on them, that's easy, but if we were called upon to list, in chronological sequence, when/where each car was made, and every place it had ever been, that would be impossible unless we had "origin and movement records". Obviously, animal traceability is completely dependent upon successful identification of individual animals or groups/lots of animals first, and origin-and-movement records thereafter. Unfortunately, especially among those in the public sector, need is expressed for a "national animal identification system" when, in truth, the US needs a "national animal identification and traceability system".

And, in some cases (e.g., branded pork, beef for export), "verification" is required. "To verify" is defined as "to prove the truth or accuracy of, or to substantiate, by the presentation of evidence or testimony". "Source-verification" requires substantiation of the origin (e.g., breed, strain, geographic area) of the livestock, poultry or meat. "Production practice verification" involves authentication of things done (e.g., grass-fed, free-range, raised/handled humanely) or things not done (e.g., no antibiotics, no hormonal growth promotants, not fed animal by-products) during rearing of the animals. The "USDA process-verification" program (Saunders, 2004a) (a) provides suppliers of agricultural products the opportunity to assure customers of their ability to provide consistent quality products; (b) is accomplished by having documented manufacturing processes verified through independent, third-party audits; and (c) enables suppliers to make marketing claims such as breed, feeding practices, or other raising and processing claims, and market themselves as "USDA Process Verified". "Beef export verification" is based upon substantiation of conditions required by an importing company, of the exporting country, as verified by the USDA Quality System Assessment (QSA) program (e.g., beef export verification, Japan; Saunders, 2005).

Golan et al. (2005) reported that (a) many buyers, including restaurants and some grocery stores, now require their suppliers to establish traceability systems, and to verify, often through third-party certification, that such systems work and (b) the growth of third-party standards and certifying agencies is helping push the whole food industry, not just those firms that employ third-party auditors, toward documented, verifiable traceability systems.

4. Means of identifying animals and meat in the US

Means of identifying livestock, poultry and their meat include (Linderoth, 2005; Marchant, 2002; Smith, 1999a, 1999b, 1999c, 2004b) (a) brands – on the hide or horns; (b) tattoos – on the ear, shoulder or lip; (c) tags – in the ear or around the tail, plastic or metal, button or dangle, plain or RFID; (d) transponders – dangling in neck chains, implanted under the skin or bolused into the rumen; and (e) biometrics – DNA fingerprinting, autoimmune antibody matching, iris scanning, retinal imaging, nose print matching, facial-recognition technology.

An advantage for retinal imaging (Optibrand™ technology) is that it combines imaging of the retina with a digital camera that is linked to an internal global positioning satellite (GPS) receiver which enables automatic encryption of date, time and location of image capture, making it virtually tamper-proof (Marchant, 2002). Linderoth (2005) reported that a recent survey by Kansas State University revealed that at least 36 companies supply animal ID products. Excellent reviews of technologies useful for identifying livestock are provided by Linderoth (2005) and Hisey (2005).

In US production practice, breeding animals and animals exhibited at shows, fairs and sales, if they are identified, have unique individual identifiers (one number for each animal) which is referred to as "individual animal identification" (IAID); while most commercial and market animals, if they are identified, have group identifiers (the same brand, eartag number or tattoo number for livestock; the same lot number or crate-tag number for poultry) which is defined as "animal group identification" (AGID). Any of the means listed above [(a)–(e)] can be used for IAID from birth of the animal through grading of the carcass so long as the packing plant uses individual-carcass identification (tagging or trolley-tracking) to maintain IAID through animal processing and carcass chilling. If though, individual animal-source identification of wholesale and/or retail meat cuts is to be accomplished, one of two things must be done: (1) The processes of animal harvesting, carcass fabrication and meat grinding must be performed at low enough speeds to allow complete separation/segregation of individual animal units. (2) Or something more than the means listed above as [(a)–(d)] must be added to the identification sequence (Smith, Belk, Scanga, Sofos, & Tatum, 2000); two of the biometric technologies (DNA fingerprinting; autoimmune antibody matching) are capable of facilitating IAID of animals, carcasses and meat from farm-to-fork.

Steinsträter and Jensen (2001), in Germany, developed a method for complete traceability in the cutting up of beef; the system consists of cutting one carcass at a time, putting all pieces in single containers, and then transporting and distributing in single carcass lots to retailers where bar-coded tags are applied to each retail cut. Their system of traceability "closes gaps and enables complete traceability from birth through rearing, slaughtering and cutting up, right to packaging, so that consumers can taste beef without restrictions and with confidence" (Steinsträter & Jensen, 2001). No question, the latter system would work, but only for very, very small-scale application . . . and at great cost.

Smith, Belk, et al. (2000) said that for branded beef programs from alliances or supply chains requiring source verification, production-practice verification or USDA process verification: (a) IAID can be used from birth of the calf to grading of the beef carcass. (b) IAID will work beyond carcass grading only if very small quantities of cattle/carcasses/cuts/trimmings are involved. (c) AGID is necessitated in medium-size and large-size packing plant and requires that enough product be involved to allow complete-shift (usually 2 h in length) carcass fabrication and trimming (thus allowing for group identification of cuts, trimmings, batches, boxes and lugs).

5. Definitions of traceability in the context of the US livestock/poultry industries

Smith (1999a, 1999b, 1999c, 2000, 2004b) said "Traceability" (also referred to as "traceback") refers to the ability to identify farm animals (livestock and poultry) and their products (especially their meat), according to their origin, as far back in the production sequence as is necessary to (a) ascertain ownership, (b) identify parentage, (c) improve palatability, (d) assure food safety, and/or (e) assure compliance (e.g., for source-verification, process-verification, production practice-verification, branded-beef program constraints, beef export verification, authenticity management)". The International Organization for Standardization (ISO), which develops voluntary international standards for products and services, defines traceability as the "ability to trace the history, application or location of what is under consideration", and says "traceability is a series of recorded identifications" (Golan et al., 2005). Clayton (2002) said traceability is defined by Codex Alimentarius as "forward and backward tracking by paper or electronic means", and emphasized that the World Trade Organization (WTO) requires that traceability, if used as an importation constraint by a country, must be scientifically justified and equal to the traceability standards applied domestically in each country. Sparks (2002) defined traceability as "The ability to follow and document the origin and history of a food product; from core genetics to the dinner plate, tracing involves identifying all procedures and practices that have impacted the life of a given product, and is documented and available for the purchaser or any other supply chain participant to see".

Saunders (2004a) said the drivers for livestock identification and traceability are (1) protecting our nation's herds and flocks – preparedness for disease and bioterrorism, to assure containment and to limit damages; (2) promoting consumer confidence – to assure market access in global trade and to deliver on brand promise via added assurances and authenticity management; (3) adding value as a benefit of supply-chain management – preservation of intended value traits created by use of genetics, origin of production, unique inputs or processing method.

IdentiGEN (2004) says: (a) within the meat industry, traceability is typically achieved through eartags, meat labels and bar-codes which identify an animal and enable products derived from it to be traced back to a production batch or to a group of animals of the same origin; (b) the latter systems can be expensive and complex, limited in precision and scope, and costly; while (c) DNA traceback technology overcomes this complexity by avoiding the need for external products and achieves traceback by using an animal's own DNA code to identify it, and products derived from it, enabling animals and meat to be traced with 100% precision. Meghen (2000) says it is clear that DNA identification technology is going to play an increasingly important role in refining existing traceability systems because it ensures that meat products can be traced to the animal of origin, but does not require that they are traced.

6. Identification and traceability systems for cattle and beef in the US and in other countries

Souza-Monteiro and Caswell (2004) summarized mandatory vs. voluntary aspects of traceability in beef supply chains in major producing and trading countries as follows: (a) EU and Japan have mandatory traceability; all beef produced domestically must be traceable backward and forward from retail to farm-of-origin. (b) Australia and Brazil have plans for general mandatory traceability but traceability is currently mandatory only for exported beef, particularly for export to EU and Japanese markets. (c) Canada has a mandatory animal identification scheme for all animals moving away from the farm-of-origin; this system establishes links between farm-of-origin and abattoir or port (when animals or products are exported). (d) Argentina has a mandatory traceability system only for beef being exported; animals and meat sold domestically do not have to be identified, unless they are produced in regions where animal diseases still persist. (e) To date, traceability is voluntary in the US.

Souza-Monteiro and Caswell (2004) characterized differences between traceability systems in terms of their depth, breadth and precision as follows: (a) The mandatory systems in EU and Japan are the deepest; they link information on the origin of the animal to the retail store through label information on the final package. (b) The Australian system does not link abattoirs to retail stores but when beef is exported, the containers and their contents are registered in the system, allowing for importing agents to use such information. (c) Brazil, Japan, Australia and EU have the broadest systems, although in most cases systems can be implemented on a broader scale on a voluntary basis. (c) Canada, and especially Argentina, have simpler traceability systems in terms of breadth. (e) Japan, EU, Australia and Brazil have developed the most precise systems as individual animals and their farms-of-origin can be linked with beef systems; all of these systems rely on verification by public or private auditors. (f) Japan is using DNA samples to confirm the accuracy of databases. (g) The Australian beef traceability system is based on electronic tagging, which is reported to be very accurate in gathering and recording information. (h) Canada and Argentina depend on the information given by farmers and processors, with no public or private verification.

Following are two examples of traceability presently in use in the US beef industry, and with which the authors of this paper have been involved. Maverick Ranch Beef (Denver, CO) uses retinal scanning to identify calves at birth and at weaning, feeder cattle upon entry to the feedlot, and slaughter cattle at the packing plant, combined with trolley-tracking of carcasses and bar-code tagging of cuts through fabrication to maintain IAID in their "Natural Beef" program. Swift & Company (Greeley, CO) is experimenting with a patented process (SwiftTrace™) that (1) uses retinal scanning to identify feeder cattle at the feedlot and slaughter cattle at the packing plant plus trolley-tracking to maintain IAID of carcasses; (2) collects and archives a muscle sample from each animal, at the time of carcass fabrication, and then, based on "individual-subprimal-cut, fabrication-to-packaging, time-windows" (e.g., 22.17 min for an oven-ready rib roast), stamps a code number on each box of cuts; (3) uses the "time window" to narrow the number of muscle samples they would need to DNA fingerprint in order to find a match with the DNA fingerprint of an individual beef cut should the need for traceback from a retail cut to the animal of origin ever arise; (4) will, over time, be extended backward to the farm/ranch of origin by retinal scanning of each calf at birth.

Hisey (2005) said "The stakes are clearly getting higher in the traceability sweepstakes, and the US livestock industry may be falling behind its international competitors. Unlike Canada, which is light years ahead of the US in animal traceability, the US is, thus far, unwilling to include information necessary to verify the date, or even the month of birth". Food Safety Network (2004) reported that Canadian farmers and the newly formed Canadian Livestock Identification Agency will, in early 2005 (1) use mandatory radio-frequency microchips and possibly, bar-coded ear or crate tags to track every major livestock species (i.e., cattle, hogs, goats, horses, sheep, bison and poultry); (2) monitor animals from the moment they are reared, each time they are sold, through inspection at the abattoir or at the border, if exported; (3) replace a "patchwork" of methods, used by industry associations to traceback livestock to the farm where they were produced, and trace forward to the supermarket shelf, with a set of mandatory standards for all species.

Talbot (2004) said "Walk into a Jusco supermarket in Yamato, a small city near Tokyo, Japan, and you can glimpse the future of meat. In addition to a conventional bar-code, each steak package sports its own ID number. Type the number into the computer sitting on a nearby table, and up pops information about the cow the steak came from; a scanned copy of its negative test result for mad-cow disease and, in case you are interested, its breed and sex, its date of slaughter, and the name of the producer. At some Japanese meat-counter displays, you'll even see a picture of the family that raised the animal. All of this information is available because the steaks come from Japanese cattle that have been individually tracked from birth, generally with RFID tags; at slaughter, the ID numbers and all data linked to those numbers, are passed on to individual boxes of meat".

Smith (2005) reported that in Korea (a) Han Naeng (Korea Cold Storage, Ltd.) packing plant uses "Transparent Traceability Assurance" to track cattle through harvest, and carcasses through fabrication, to maintain IAID through to primal cuts for retail distribution; (b) National Agricultural Cooperative Federation supermarkets use "Transparent Traceability Assurance" featuring point-of-purchase material emphasizing "DNA traceability of beef" and with kiosks located in the meat markets that feature "ID computerized screens". Shoppers can enter the bar-code number from individual beef-cut packages into the computer to learn name/location of farm, name of breeder, castration date, weaning date, date/location of packing plant at which harvest occurred, and many other details of farm-to-fork traceability; (c) The Korean Ministry of Information and Communication has directed customs officials (National Veterinary Research and Quarantine Service) to attach RFID tags to all cartons/boxes of all beef generated domestically and of all imported beef as it passes through customs; (d) Sang-Hyup Cha (CEO of Han Naeng) said "We believe 98% of retail customers have no interest in traceability at present, while 2% want to know the beef is from Hanwoo (Korean beef cattle breed) and not from Jeotso (Korean dairy cattle breed) but when beef from North America re-enters our markets, many more retail customers will be checking to see if the beef is from Korea or from one of the countries that has had BSE cases".

Saunders (2004a, 2004b, 2004c, 2004d, 2005) believes that for cattle and beef, the US must move forward with a four-pronged approach to traceability: (1) Identification and traceability as a means of traceback in the event of an animal disease outbreak – within the scope of this objective it is, in its entirety, related to the capture and transfer of information critical to conducting a rapid traceback to limit economic damages (and potentially, public health problems); there is no need to do trace-forward beyond the harvest floor. (2) Identification and traceability as a means of adding assurances, building brand features and benefits, and enabling more in-depth marketing to the consumer – meat companies are attempting to capture traceability information and then move it forward, beyond the harvest floor to retail outlets, using DNA fingerprinting. (3) Identification and traceability as a means of improving product quality by sending economic signals back through the production and supply chain – though the strongest economic signal being sent by packers backward through the production/management sequence, is for additional weight,

there are rewards for quality grade, yield grade, absence of defects and compliance with branded-beef program constraints. (4) Identification and traceability as one element within the larger scope of product attribute documentation and process verification – this movement is driven by the necessity to add assurances to the end-purchaser, and allows for "identify preservation" which is a key component of USDA Quality System Assessment (QSA), process verification program (PVP) and Beef Export Verification (BEV) endeavors, as well as ISO compliance and beef quality assurance (BQA) efforts. Saunders (2005) believes the key will be to build a national identification and traceability infrastructure, in the US, that limits duplication yet allows all four of the above-mentioned efforts to proceed.

7. Breadth, depth and precision of traceability systems

Golan et al. (2005) said: (1) No food traceability system is complete because food is a complex product and traceability is a tool for achieving a number of different objectives. (2) A system for tracking every input and process to satisfy every objective would be enormous and costly; consequently, firms across the US food supply system have developed varying amounts and kinds of traceability. (3) Firms develop the necessary breadth, depth and precision of their traceability systems depending on characteristics of their production process and their traceability objectives. (4) The breadth of a traceability system relates to the amount of information collected; attempting to keep records and to catalog every characteristic and/or event is not usually warranted and would be prohibitively expensive. (5) Depth of a traceability system is defined as how far back and/or forward the relevant information is tracked; if, for example, food safety is at issue, depth would be determined by the number/location of Critical Control Points in the production/distribution chain. (6) Precision reflects the degree of assurance with which the tracing system can pinpoint a particular food product's movement or characteristics; in some cases, the objectives of the system will dictate a precise system while, for other objectives, a less-precise system will suffice.

Traceability in its broadest context, applied across the entire complex of livestock, poultry and meat industries, and encompassing birth of the animal to human consumption of the animal's body-parts, can, could, or will eventually, be used (1) to ascertain origin and ownership, and to deter theft and misrepresentation, of animals and meat; (2) for surveillance, control and eradication of foreign animal diseases (FADs); (3) for biosecurity protection of the national livestock population; (4) for compliance with requirements of international customers; (5) for compliance with COOL requirements; (6) for improvement of supply-side management, distribution/delivery systems and inventory controls; (7) to facilitate value-based marketing; (8) to facilitate value-added marketing; (9) to isolate the source and extent of quality-control and food-safety problems; and (10) to minimize product recalls and make crisis management protocols more effective. At issue, as the US develops traceback capabilities, will be the breadth, depth and precision of its specific traceability system. Golan et al. (2005) discuss breadth of a hypothetical beef traceability program saying "Even a beef tracking system in which consumers scan the package of beef at the checkout counter and access the animal's date and location of birth, lineage, vaccination records and use of mammalian protein supplements is not complete. This system does not provide traceability with respect to bacterial control in the barn, use of genetically engineered feed, or animal welfare attributes like hours at pasture and play time". The amount of information collected (i.e., the breadth of the system) must always be reconciled with the details (for which data are collected and archived) about which purchasers and/or consumers are interested.

For the livestock, poultry and meat industries, "life-cycle traceability" (as it pertains to the depth of traceability systems) does not necessarily pertain to all 10 of the "uses" identified above, in every application of traceback activities. For example, origin and ownership of live animals; surveillance, control and eradication of certain FADs – e.g., foot-and-mouth disease (FMD) but not bovine spongiform encephalopathy (BSE) – and bioterrorism deterrence – e.g., to prevent use of FMD to threaten the stability of US agriculture – might be accomplished with identification and traceability only to the level of the live animal and with no need for either identification or traceability through packing, processing or retailing sectors. Moreover, value-based marketing might involve identification and traceability only from farm, or finishing facility, through evaluation of carcasses and/or meat at the packing or processing sectors. Of the 10 "uses", life-cycle identification and traceability would be most applicable for items (from the list above) (No. 1) if it was to apply to meat; (No. 2) if it is a disease communicable to humans; (No. 3) if the agent used in the bioterroristic event could harm humans; (No. 4) if international customers feared presence of chemical residues (e.g., from use of hormone implants) or disease agents (e.g., BSE prions), or that the meat came from animals that were genetically modified or were fed a diet containing GMOs; (No. 6) if producers, packers and retailers were partners in a supply-chain or alliance; (No. 8) if added-value was dependent on credence attributes; (No. 9) if the quality or safety problem could have originated at farm level; and (No. 10) if the cause of the recall could have occurred at farm level. By definition, item (No. 5) requires life-cycle identification and traceability because COOL involves descriptors

for "born in", "raised in" and "processed in" as parts of the label declaration. Suffice it to say that not all potential or possible applications of identification and traceability, for use in the livestock, poultry and meat industries, are intended to cover the entire "life-cycle".

With regard to precision, pinpointing the degree of assurance with which a particular food product's movement or characteristics can be produced, the two extremes can best be illustrated with examples from the beef sector. To assure that branded beef qualifies as "grass fed", producer affidavits would suffice, while to assure that Japan receives no US beef from cattle older than 20 months-of-age and with all Specified Risk Material removed during harvest/fabrication requires validation; for the former, the degree of assurance is imprecise, but sufficient, but for the latter, the precision of USDA Beef Export Verification is an imperative. Verification (source, production practice, process, or beef export) could be used effectively for items – No. 1, No. 4, No. 5, No. 7, No. 8 and No. 9 – from the list above.

8. Traceability to ascertain origin and ownership, and to deter theft and misrepresentation, of animals and meat

For centuries, husbandmen have identified their livestock, but not usually their poultry, using marks, notches, brands or tags, in order to be able to claim (and prove) ownership and to deter theft (e.g., rustling of livestock). There are, however, far too many livestock producers in the US who do not identify their animals and even more who do not keep records of ownership, birth, movements or sales-transactions. Especially if their animals are grouped for sale (e.g., feeder cattle, sheep and swine, as well as market-ready lambs, hogs, broilers and turkeys) as they leave the farm or ranch, IAID is almost never done and AGID is seldom done except if it is a condition of sale or payment. So, in the US, identification of livestock, on or leaving a premises is voluntary, not mandatory. In other livestock and poultry industry sectors (e.g., packing, processing), identification and traceability is not presently used to deter theft or misrepresentation but soon will be, given the direction taken by retailers like Wal-Mart (Feder, 2004; Food Production Daily, 2004).

9. Traceability for surveillance, control and eradication of foreign animal diseases

The US livestock industry has a long history of identifying and tracking animals to control the spread of animal diseases (by government mandate). In the 1940s, USDA initiated a national program to identify (with an official vaccination tag and a tattoo in each animal's ear) cattle vaccinated for brucellosis (APHIS-USDA, 2004a). Other US animal health programs include an animal identification component, and certain species/classes of livestock must be identified before entering interstate commerce. Hoffman et al. (2004) discuss, as a part of the Sheep Safety&Quality Assurance Program, the Voluntary Scrapie Flock Certification Program which is an option for which progressive sheep producers may enroll to monitor the scrapie status of their flock; animals must be individually identified, accurate record-keeping is necessary and enrolled flocks are monitored for five consecutive years before they are deemed a certified scrapie-free flock. Regulations of the USDA National Scrapie Eradication Program (NSEP) require that if a producer has scrapie confirmed in his/her sheep or goat flock, all animals must be officially identified and entered in the USDA Scrapie National Database and there are very stringent restrictions on moving such animals in interstate commerce (USDA/AASRP/NIAA (2004)). Miller (2004a) reported that the swine industry has had mandatory IAID for replacement breeding stock (boars, sows, gilts), moving in interstate commerce, for 16 years.

Weimers (2000) detailed a proposed state/federal/industry cooperative National Livestock Identification System (NLIS) based, in part, on public need for ongoing surveillance/eradication programs for FADs (e.g., classical swine fever, FMD, BSE, scrapie, avian influenza). Moreover, Weimers (2000) described (1) the essential elements of a national animal identification system as (a) a numbering system, (b) a database, (c) an identification method, and (d) a method to collect and transmit data, as well as; (2) the ideal system for "individual-animal and transaction identification" as consisting of (a) unique individual identification of animals, (b) herd-of-origin identification (the premises where the animal originated), (c) lot identification (when animals are in separate groups on the same premises), (d) transaction identification, and (e) identification of any other premises in which the animal may have been between birth and slaughter.

Bailey (2004) reported that (a) the National Identification Work Plan (NIWP) was the first public effort in the US to examine possible implementation of a national animal identification system; (b) NIWP started as a Task Force, formed in April 2002, comprised of representatives of more than 30 livestock organizations and coordinated by the National Institute for Animal Agriculture (NIAA); (c) the NIWP was accepted by the US Animal Health Association (USAHA) in October 2002; (d) using the NIWP as the prototype, representatives of USAHA, APHIS-USDA and industry began development of the US Animal Identification Plan (USAIP) in October 2002; and (e) in October 2003, USAHA approved the USAIP, which called for establishment of individual premises identification by summer 2004, individual animal identification by 2005, and full

implementation and compliance (all covered species; intrastate and interstate commerce) by July 2006.

Paige (2003) characterized the USAIP as "an identification system that, through established standards and defined data elements, allows for the compatibility of systems while providing the efficient availability of agreed-to information across each segment of the animal agriculture industry" and also said that the Animal Health working groups of NIWP and USAIP had agreed on a "traceability time-frame" which was "a time requirement (48 h) for trace-back to the farm of origin and last farm/company of ownership". Smith (2004c) said animal ID will not prevent a FAD from entering the US, but it will help the nation recover faster…especially from a fast moving FAD like FMD.

Salant (2003) reported that a single Holstein cow, on a Washington state farm, had tested positive for BSE, marking the first appearance of the brain-wasting disease in the US. According to APHIS-USDA (2004a), the increasing number of animal disease outbreaks that have been reported around the globe over the past decade, and the single US cow that tested positive for BSE, have greatly intensified public interest in developing a national identification program for the purpose of protecting animal health. Marshall (2004) reported that USDA Secretary Ann Veneman announced on April 30, 2004: (a) USDA will now move forward on a National Animal Identification System (NAIS) using $18.8 million to start the program and with $33 million more in the FY-2005 federal budget, (b) the framework will be "technology neutral" but RFID will be the method of choice to get the program going as soon as possible, (c) the USAIP will be modified to protect producer confidentiality [against inappropriate use of the Freedom Of Information Act (FOIA)], and (d) NAIS will initially be voluntary, with premises IDs assigned in Fall 2004 and individual animal IDs used at a later date.

APHIS-USDA (2004a) says the goal of NAIS is to have the capability to identify all animals and premises that have had direct contact with an FAD or a domestic disease of concern, within 48 h after discovery. Species included in this voluntary program are camelids (llamas and alpacas), cattle and bison, cervids (deer and elk), equine, goats, poultry, sheep and swine; every animal needing to be identified individually will have a unique numerical identifier while species that normally move through the production chain in large groups, such as swine and turkeys, may be identified through use of a single group or lot numerical identifier (APHIS-USDA, 2004a). The first step in implementing NAIS is identifying and registering premises that are associated with the animal agriculture industry (APHIS-USDA, 2004b). The identification of premises that allow for the commingling of animals (i.e., production points) is the foundation of the NAIS and must be established before animals can be tracked; after premises are registered, unique animal identification numbers will be issued to individually identified premises (APHIS-USDA, 2004b).

Hillman and Hammerschmidt (2005) described "a premises" as a location where animals are raised, held or boarded; ideally, each distinct location would be identified with a unique premises number. At a minimum, the "home place" in which animals are raised needs to be registered for the operator to obtain a unique premises-identification number; additional locations are not required to be registered at this time, although it is highly encouraged (Hillman & Hammerschmidt, 2005).

Denis (2004) testified before the US House of Representatives, representing the American Sheep Industry Association (ASI), and said that the ASI (a) endorses the concept of a mandatory national identification program for livestock, as outlined by the USAIP development team, the USDA and US Department of Homeland Security (USDHS); (b) believes the public sector should pay for the cost of identification supplies and devices; (c) believes the national ID system for sheep should accommodate all of the various production systems used in the US including group movement of animals for management purposes; and (d) believes that the national ID system for sheep should contribute to the management, marketing and business needs of the US sheep industry.

Smith (2004a) testified before the US House of Representatives representing the International Stockmen's Educational Foundation, and said that the International Livestock Congress (ILC) and International Beef Industry Congress (IBIC) had historically supported traceability, concluding (1) at the 2002 ILC, that IAID and traceability were useful for source verification, process verification, control of FADs and prevention of agricultural bioterrorism; (2) at the 2003 ILC, that traceability was important for price linkage, product safety, eating quality, value determination and product consistency; (3) at the 2003 IBIC, that implementation of a traceability system in the US is inevitable and necessary for performance tracking, source verification, food safety and protection of the public health; (4) at the 2004 ILC, that a verifiable nationwide animal identification system is essential to enhance the speed and accuracy of our response to disease outbreaks (e.g., BSE).

Ohio Department of Agriculture (2004) discusses the NAIS as applied to swine saying premises identification, individual or group/lot identification, and animal-movement reporting will create an infrastructure to improve efforts for disease eradiation and control. Lawrence (2005) described the proposed implementation timeline for NAIS as follows: (1) Introduction 2004–2005, to include (a) establish premises ID system, (b) begin education and outreach activities, and (c) conduct test strategies. (2) Infrastructure 2005–2006, to include (a) establish information technology infrastructure, (b)

establish RFID reader infrastructure, (c) implement tag distribution system, and (d) initiate identified-cattle report movements. (3) Implementation 2007, to include (a) test analysis and validation of overall program, (b) determine critical mass to achieve goal, and (c) initiate required participation with government funding.

Miller (2004a) described NAIS specifics for the pork industry giving advice to pork producers as follows: (a) Register your premises. (b) Keep production records now, including animal movements. (c) Maintain records locally so that when the national system is in place, you will be prepared to release those records and sell your pigs immediately. Sheep and Goat Health Report (2004) concluded that the US sheep industry endorses the concept of mandatory national identification of livestock but desires that the US government recognize that the sheep industry has a national animal health program in place that already includes a mandatory identification system (the federal scrapie eradication program) and utilize that program as a solid model for fitting the US sheep industry into a national animal ID system.

Meat Marketing and Technology (2004) reported that USDA is presently trying to sort out the following points that have triggered great debate on the NAIS: (a) confidentiality of the data, (b) costs for implementation of the system, (c) premises identifiers (one for each premises owned by a single entity vs. one number to cover several premises owned by a single entity), and (d) technology requirements (USDA has said that the minimum requirement is a tracking number, the animal's date of birth and the date it was slaughtered). Smith (2004c) said "NAIS won't require IAID on most market hogs; for hogs going directly to slaughter, their movement can be tracked with AGID. The swine industry, then, must identify market hogs back to the last premises, must improve identification of cull sows and boars, and must develop more effective IAID systems for purebred swine and show pigs (because they have so often been commingled)".

NIAA (2004) conducted a national survey of its members and reported the "biggest concerns about the NAIS" as (1) funding, 20.5%; (2) producer participation, 16.7%; (3) data confidentiality, 15.2%; (4) data collection and housing, 10.6%; and (5) voluntary vs. mandatory program, 4.6%. Asked specifically about a voluntary vs. mandatory program, 53.8% were in favor of a voluntary program during development but with a decided date for making the program mandatory; asked who should control the database, 28.0% supported a decentralized database system operated by state animal health agencies while 27.3% want a centralized database operated by USDA (NIAA, 2004).

Commenting on results of the NIAA (2004) survey, on behalf of the pork industry, Miller (2004b) said it is encouraging that a large number of stakeholders (a) believe they are ready to participate in the NAIS, (b) say the program is not moving fast enough, and (c) want NAIS to become mandatory at some point. As early as 2000, Dr. John Weimers (Director for National Animal Identification, APHIS-USDA) was quoted (Feedstuffs, 2000) as saying "APHIS believes national identification needs to be in place in 3 years; we'd like to bring it on voluntarily, but APHIS plans to propose a mandatory system, if industry lags".

10. Traceability for biosecurity protection of the national livestock population

APHIS-USDA (2004a) says a rational, cost-effective animal identification program will improve biosecurity protection of the national livestock population. Peter Chalk, a policy analyst with RAND Corporation, said (Reuters, 2001): (a) more must be done to protect the US agriculture industry and food supply from attacks by extremists; (b) we have a highly critical sector that is vulnerable, and it is not that difficult to exploit that vulnerability; (c) an attack on the nation's food supply could have a devastating impact on the economy and damage consumer confidence; (d) the introduction of an FAD into a cattle feedlot (e.g., BSE) or large hog farm (e.g., FMD) would set off a tidal wave of effects; (e) the concentration of many animals, that makes US livestock facilities so efficient, is also a security liability; and (f) USDA would not be able to quickly and effectively contain an outbreak because they do not have the ability to institute local preparedness programs. Agnosco (2003) said "Increased concern that a FAD might occur in the US has accelerated interest in traceability because, without it, it would be impossible for animal-health officials to quickly identify, isolate and contain an outbreak".

Smith (2001) reported that an assault on our food supply through either biological weapons or the introduction of an FAD would be a highly destructive force; the greatest deterrent to a bioterroristic act on US animal agriculture is to have in place a national animal identification and traceability system that would allow us to quickly contain a catastrophe. Traceability of livestock, poultry and their meat creates an identification trail for the USDHS to follow should the need arise. Golan et al. (2004) believe that mandatory tracking of livestock/poultry feed and of food transportation systems could help control risk of BSE spread, tampering and potential bioterrorism. Miller (2005) believes that biosecurity and national security, FADs, exotic diseases and emerging diseases are real-world concerns for the US pork industry; as the pork industry continues its growing commitment to the export market, the importance of animal ID, herd health and national security will only deepen. Hibbert (2005) suggested five things the US could do to minimize possibilities of food bioter-

rorism; among those were "cross-checking", development of effective border control systems and post-import routing of product, all of which would necessitate development of effective tracking systems.

11. Traceability for compliance with requirements of international customers

Saunders (2004b) reported that international agencies are stepping-up the pressure on identification and traceability, with the WTO stating that the importing country cannot enforce more rigorous standards for imported meat than those applied to the domestic industry or use these standards as trade barriers, and the Office of International Epizooties asking countries to agree to international codes and standards (with traceability as a key element) that will provide better guarantees and facilitate trade in animals and animal products. Souza-Monteiro and Caswell (2004) concluded that: (1) If markets where traceability becomes the standard pay higher prices, then exporting countries would be willing to adopt traceability as long as any higher costs are fully recovered; however, exporting countries with strict traceability could lose markets where traceability is not required because likely higher prices will hurt their competitiveness in those markets. (2) This raises the important issue of harmonization of traceability systems; harmonization would likely reduce disputes and lead to more transparent transactions but would also fail to accommodate regional differences in needs for such systems.

To protect their financial investment, export customers are demanding that their suppliers traceback food products to source-of-origin. Governments of other countries attempt to protect the health and well-being of their citizens (Clayton, 2002) using non-tariff trade barriers like the "Hormone Ban" (against beef from cattle given hormonal growth promotants) by the EU, and in other cases using cattle age (against beef from animals older than 20 months-of-age by Japan or 30 months-of-age by Canada and Mexico).

Drovers Alert (2004) reported that a Japanese group, who had just visited North America said (a) resumption of full-scale beef trade with Canada is highly likely because it already has a nationwide tracking system on cattle and (b) American beef imports, however, will be limited because of lack of traceability and lack of age verification. The problem is the inability of the US to accurately identify the age and origin of its animals.

Retail distribution channels are requiring more information about the products they are receiving and export customers are beginning to demand that their suppliers traceback products to original sources in order to protect the customers' investment in their own brand equity (Fordice, 2004). Meat export verification requires that all elements of an agreement between/among countries regarding animals/meat/by-products acceptable for international trade be independently audited. The Auditing, Review & Compliance (ARC) Branch of AMS-USDA has previously designed Beef Export Verification (BEV) programs for the export of beef to other countries (none of which involved animal identification and traceability) and is presently developing a new BEV program for Japan. It (AMS-USDA, 2004) sets forth (as one of two options, animal traceability or physiological age) that "bovine animals must be traceable to live animal production records which indicate that they are 20 months-of-age or younger at the time of slaughter, using records (individual animal age verification, group age verification, insemination age verification or USDA Process Verified Animal and Data Collection Services records) to verify this requirement.

12. Traceability for compliance with country-of-origin labeling requirements

The US Congress mandated (AMS-USDA, 2002a) Country-of-Origin Labeling (COOL; also called MCOOL for Mandatory COOL) for many food crops/products (including ground and muscle cuts of beef, pork and lamb, but not poultry) in the 2002 Farm Bill. Those in the livestock industry who fought hardest to gain passage of COOL, in general, believed all that would be required was identification by country-of-origin of all imported livestock (at any age) and their ultimate products plus all imported meat from affected species, allowing all other meat in the US, from those species, to be labeled as "Born, Raised And Processed In The USA" but the US government did not agree. When "Rules for Country-of-Origin Labeling" were later released it was obvious to all that industry had "reaped a whirlwind". COOL required that "a retailer of a covered commodity shall inform consumers, at the final point of sale of the covered commodity to consumers, of the country of origin of the covered commodity". COOL prohibits the USDA Secretary from mandating an animal identification program for verification of country-of-origin; it is, in fact, a marketing program designed to provide information regarding the country-of-origin of certain foods, to consumers (AMS-USDA, 2002a).

Premium Standard Farms announced on May 30, 2003, fully 16 months ahead of the September 30, 2004 date on which COOL for pork and other commodities was to become mandatory, that it was starting to supply COOL-compliant pork to supermarkets; the company said its COOL plan dove-tailed with its USDA Process-Verified pork program in which source-verification is a key element (Meatnews, 2003). Participants in the sheep safety and quality assurance program (SSQAP)

are instructed, relative to record-keeping requirements, to assure that they are in compliance with rules and regulations of both COOL and USAIP/NAIS (Hoffman et al., 2004).

Umberger (2004) said the US beef industry is split over whether a COOL program should be voluntary or mandatory and, if it is mandatory, whether or not it would be beneficial. Producer proponents believe COOL could (a) create a competitive, differentiated market for US beef; (b) increase market share for US beef because US consumers would favor it over beef of foreign-country origin; (c) fulfill US consumers "right to know" where their food products originate; and (d) provide consumers with increased food safety assurance (Umberger, 2004). Producer opponents believe COOL (a) would be too difficult and costly to implement; (b) could reduce beef demand because costs would be passed on to consumers causing them to shift consumption away from beef and to poultry (which is exempt from COOL); (c) might result in some consumers developing a taste for international, imported food products, thus reducing beef demand; (d) would constitute a non-tariff trade barrier that could reduce beef export demand because it would violate both WTO and NAFTA regulations; (e) is not based on evidence of consumer demand for such labeling and thus is unnecessary; (f) is, as codified, "the law of unintended consequences" because the products (e.g., poultry) and institutions (e.g., foodservice establishments) exempt from COOL regulations create an unfair advantage for poultry and allow 40% of all beef sold in the US to not be identified as to country-of-origin (AMS-USDA, 2003; Loureiro & Umberger, 2004; Umberger, 2004; Umberger, Mark, & Feuz, 2003b).

Numerous estimates of costs and benefits of COOL were made, including that by AMS-USDA (2002b) of at least $1.9 billion for the first year; US Government Accounting Office (2003) reported that the $1.9 billion underestimated the real cost. Among the best of the estimates was that described by Caspers (2003) as follows: "On October 27, 2003, USDA released a new cost-benefit analysis of COOL that says (a) cost in the first year will be $4 billion for all covered commodities, (b) research validates producer concerns that consumers are not willing to pay a price premium for products bearing US origin labels, (c) some major US meat trading partners will file challenges to the WTO, and (d) research fully supports that there is no evidence that COOL will benefit producers, packers, retailers or consumers".

Sitz, Calkins, Umberger, and Feuz (2004) reported that a majority (69.2%) of consumers in Denver and Chicago preferred a fresh beef strip steak with a label guaranteeing the meat came from a US animal over an unlabeled steak. On average, consumers were willing to pay 18.7% more ($0.81/lb) for labeled product. When 17 attributes were rated for their desirability when purchasing beef, COOL ranked ninth; "freshness" and "inspected for food safety" were the most popular selection criteria (Sitz et al., 2004). However, if only 69% of consumers (Umberger, Feuz, Calkins, & Sitz, 2003a) were willing to pay a premium for US beef, premiums for US beef would not exist, because supply (89% of all steaks and roasts, and 75% of all beef trimmings, that are sold in the US each year are of domestic origin; Plain & Grimes, 2003) would exceed the quantity of US beef demanded by US consumers (Umberger, 2004).

Reagan et al. (2003) characterized the problems associated with implementation of COOL in the US as (1) the inadequacy of US traceability systems for cattle, (b) the inadequacy of US physical infrastructure (e.g., holding pens, beef coolers), (c) trade barrier consequences and potential retaliation by other countries, NAFTA and WTO as well as possible changes in the competitive structure of the global market, (d) product displacement factors and how to sell products to domestic or international buyers in competition with other sources that have complete information on origin, and (e) need for "phase-in processes" which will require 4.5–5.5 years to implement the verification system for COOL. It is presumed that if the COOL law is actually enacted, the ARC Branch of AMS-USDA will perform source-verification and auditing services regarding the geography of where animals are born and raised, and where their end-products are processed, for those in the private sector.

For fish and shellfish, COOL was supposed to start on September 30, 2004 but USDA missed the deadline and published an "Interim Final Rule" in October, 2004 (Joy, 2004) that is to become effective on April 4, 2005. COOL is exceptionally unpopular with meat packers, retailers and others; a bill called the Food Promotion Act of 2004 attempted to repeal the existing mandatory COOL provisions of the 2002 Farm Bill and direct USDA to substitute a voluntary program (Joy, 2004). Drovers (2004) recently reported that the attempt to include the Food Promotion Act of 2004 in the 2005 Omnibus Spending Bill failed, leaving COOL on track to begin for all other covered commodities on September 30, 2006. The exact specifications of the final rule for COOL will be crucial to the pork industry; with many Canadian feeder pigs being fed in the US, how that pork is labeled and whether it is discounted, will be important (Pork, 2002).

13. Traceability for improvement of supply-side management, distribution/delivery systems and inventory controls

Golan et al. (2005) said: (1) Electronic coding systems, from the elderly barcode system to cutting-edge technologies like RFID are helping to streamline the

US food-supply system. (2) As technological innovation drives down the cost of these devices, more firms across the food-supply chain are using electronic tracking systems. (3) In some cases, buyers manage these systems to monitor internal supply flow; in others, firms establish systems that link suppliers and buyers allowing them to automate re-ordering. (4) Retailers such as Wal-Mart have created proprietary supply-chain information systems, which they require their suppliers to adopt.

Major retail outlets, as a part of supply chain management, are demanding a more responsive supply chain to reduce extra inventory held in their stockrooms; to be in compliance with requirements and mandates like those being imposed by Wal-Mart, supply chains are evolving just-in-time (JIT) production systems using well-implemented product tracking and tracing solutions (Fordice, 2004). Neff (2005) said "A recent A.T. Kearney report concluded that more progressive food and other packaged-goods manufacturers have spent the past several years on supply-chain efficiency efforts installing warehouse management system, labor-scheduling and inventory-control systems but, for the manufacturers, the incremental value of RFID/EPC (electronic product code) case tagging is minimal. Widespread adoption of RFID/EPC is unlikely to occur until the industry addresses the unfavorable economics and unequal distribution of costs and benefits for manufacturers".

Gledhill (2002) said: (1) Today's meat traceability software systems can enable producers to track meat products all the way from the animal's birth to the supermarket display case and every step along the way. (2) Using bar-coded eartags or other electronic identifiers for tracking, a company can work collaboratively with its supply-chain partners to capture and hold information about individuals, or groups. (3) With information gathered and stored automatically in computer systems, producers can quickly retrieve the name/location of the farm or ranch, the meat grade, the fat content, etc. (4) After slaughter, the carcass travels through various stages of processing with new information gathered via bar-codes, RFID and label printing processes and entered into the database. (5) The complete traceability system enables capture of information relative to yield variables, for supply-side management and maximization of profit, and, when integrated with enterprise software, it allows producers to tap into this store of information to aid in managing product planning, procurement, financials and business intelligence. Golan et al. (2005) said US companies spent $1.6 trillion on supply-related activities in 2000 including the movement storage and control of products across the supply chain; supply-side management and traceability are being used at present in attempts to reduce such costs.

Firms like Escort Memory Systems (2004) offer RFID solutions for every link in the supply chain to exchange data between a portable memory device and a host computer with the RFID system in a tag or label; such systems have application in quality control, warehousing, logistics and inventory management as both tracking and data collection systems. In the meat industry, Videojet Technologies (National Provisioner, 2004) provides RFID tag application solutions to meet the Wal-Mart supplier specifications. At least one of the five largest-volume red-meat packing/processing firms is presently installing an Escort Memory System as a part of its effort to develop life-cycle traceability and supply management systems. Neff (2005) concluded that RFID technology itself will not likely generate a competitive advantage for any company but that the advantage will come from another supply-chain issue, data synchronization, matching data of food companies and their retail customers, i.e., the advantage will come from the way we use the data and manage business process change. Nevertheless, Food Production Daily (2005) reported that both food suppliers and manufacturers have been won-over to RFID technology and its usefulness for supply-chain management and inventory control and are set to scale-up and integrate RFID into their normal operations this year.

Traceback is important for determining compliance in branded-meat programs that require source-verification, production practice-verification and/or process-verification. Smith, Belk, et al. (2000) said: (a) hide branding, ear tagging (metal, plastic, electronic), tail tagging and retinal imaging would allow IAID up to slaughter; (b) IAID could be maintained through slaughter by animal/carcass tagging or trolley tracking; (c) IAID could be maintained through fabricating/boning by keeping units separated (small plants), by tagging (medium-size plants) or by DNA fingerprinting (large plants); and (d) DNA fingerprinting could be used to maintain IAID of meat products through retail sales. AGID could be used for traceback from farm-to-fork for groups/lots of livestock/poultry which are handled contemporaneously (with no animals added to the group/lot at any point in the life/death/processing cycle), using the same means of identification as are listed above for IAID with the exception (and advantage) being that all animals, carcasses, cuts and meat trimmings could have a single (and the same) identification number (Smith, 1999a, 1999b, 1999c; Smith, Belk, et al., 2000).

If, in fact, food supply management is benefited by "an information trail that follows the product's physical trail" (Simchi-Levi et al., 2003), "life-cycle traceability" (Gledhill, 2002) and/or substantiation (validation/verification) of "credence (content or process) attributes" (Golan et al., 2004) then would not AGID fulfill all of those requirements as well as, yet much more economically than, IAID? What is it about knowing the parentage and exact birth date of each animal that would

improve meat supply management, when every other event or practice (by time and place) is a part of the documented information trail. Failure to see benefits of IAID, as opposed to AGID, as a means for improving supply-side management or constructing lower-cost distribution systems has prevented action by some US livestock/poultry producers, packers and processors to move forward an IAID traceback agenda.

14. Traceability to facilitate value-based marketing

In 1999, NCBA proposed development of a National Cattle Identification System (NCIS) as "a voluntary national identification system with the ability to maintain individual records on cattle from birth to rail in order to facilitate value-based marketing" (Drovers Feeder Management, 1999). Weimers (2000) described need for a National Livestock Identification System (NLIS) based, in part, on private need to assist producers in maximizing the profit of their agricultural enterprise and assuring its sustainability by identifying those animals that consistently grow as quickly as possible, eat the least amount of feed, require the least amount of medical treatment, produce the best grading carcass, produce the most meat, milk, eggs, etc.

A tactic identified at the Strategy Workshop for the National Beef Quality Audit in 2000 for improving the quality, consistency, competitiveness and market share of beef (Smith, Savell, Morgan, & Montgomery, 2000) was "Develop and implement a voluntary industry-driven, standardized electronic individual animal identification system that is tied to a seamless system of transmitting information up and down the production, processing and distribution chain". Sheep producers involved in the SSQAP must keep records, and to facilitate record-keeping, they must eartag each ovine animal in their flock; the number in the eartag can be that of a group (for animals handled contemporaneously while on that farm or ranch) or for an individual (Hoffman et al., 2004). This provides ample opportunity for development of value-based marketing of sheep and their products.

15. Traceability to facilitate value-added marketing

As they troll down the aisles of the supermarket or ponder over which foodservice establishment to patronize, under no pressure at all to purchase/consume food about which they feel uncomfortable, food customers are progressively more often thinking about the details of the production and processing of specific food items. In the US, the beef industry has very effectively capitalized on use of the advertising slogan: "Beef, It's What's For Dinner™". As an indication though, of how and in what direction the US consumer has changed, Food System Insider (2004) quoted Elaine Lipson of Ms. Magazine (July 1, 2004) as saying, "What's for dinner?...is just too simple a question for anyone to ask these days. What's for dinner...where did it come from...who grew it...and did they use toxic and persistent pesticides or genetic modification"?

Smith (2004b) reported that, at the National Meeting of the American Chemical Society in August 2004: (a) Michael Olson (MetroFarm Communications) said "In the US, food now travels an average of 2000 miles from where they grow it, to where they eat it". (b) "Make that tens of thousands of miles for food from other countries that is exported to the US" said Claudia Chaisson (Chaisson Scientific Advisors). (c) "Consumers are asking...Can I take action to make my (my family's) food safer than standards set by federal regulators?" said Joe Rosen (Rutgers University). Saunders (2004a) quoted Grocery Headquarters as stating "People want to know where their food came from, and if there's some authenticity or familiarity, that's safer in people's minds".

An international study of consumers' perceptions of food safety, today vs. 10 years ago, reported that, of consumers in the US, Mexico, China, Japan, South Korea, Taiwan, Germany, Italy, Spain, UK and Russia: (a) 28%, 24%, 30%, 19%, 22%, 25%, 32%, 50%, 44%, 32% and 8%, respectively, thought food was "more safe", while (b) 24%, 62%, 56%, 52%, 58%, 50%, 39%, 35%, 35%, 33% and 64%, respectively, thought food was "less safe" (Beef, 2004).

NCBA, in 1999, proposed development of a National Cattle Identification System to facilitate value-based marketing, but with a secondary goal of achieving source verification (Drovers Feeder Management, 1999). Smith and Morgan (1999) reported that traceback is important for determining compliance in branded-beef programs that require source-verification, production practice-verification and/or process-verification. Source-verification refers to documentation of location-of-the-animal history from birth to harvest. Production practice-verification requires that all claims (e.g., not fed antibiotics, no added hormones, fed a vegetarian diet) made in meat marketing be independently audited. Process-verification requires that a plan be developed by those who produce, process and market a meat product for which claims are made (e.g., specific production practices, freedom from certain chemical residues, guaranteed tender) and subsequent independent auditing to assure compliance. In the US, private entities can perform their own source, production practice and process, verification as well as validation and auditing, but cannot perform their own meat export verification. AMS-SDA has an Auditing, Review And Compliance (ARC) Branch which performs services on a fee basis for process-verification and meat export-verification.

Golan et al. (2004) believe that many valuable animal attributes are not evident to the naked eye or even to specialized equipment. Credence attributes (e.g., up-to-date vaccinations, proper medical care, animal welfare provisions, avoidance of growth promotants/antibiotics/animal by-products, specific feeding regimen) may increase the value of an animal. Fraley (2004) described the NAIS as applied to swine, emphasizing that the program is initially voluntary, that pork packers will need to utilize NAIS-compliant identification systems, and that, although it is not the primary purpose of NAIS, producers, packers and retailers will be able to capture and track valuable information which may be used to add value to livestock.

AMS-USDA (2001) developed, and solicited comments on, proposed minimum requirements for livestock and meat industry production/marketing claims; specifically, USDA proposed that these would then be allowed in voluntary AMS Certified and/or Process Verified programs. Claims relating to live animal production included (AMS-USDA, 2001) (1) animal identification (traceability), (2) antibiotic, (3) breed, (4) free range, (5) geographic location, (6) grain fed (corn fed), (7) grass fed, (8) hormone, (9) pre-conditioning, and (10) vitamin E; claims relating to product characteristics included (1) aged meat, (2) electrical stimulation and (3) tenderness. Numerous comments were received, and opinions were quite disparate. Marty O'Connor (AMS-USDA, personal communication, January 13, 2005) said USDA will, in early 2005, release requirements for animal identification/traceability, geographic location, grain fed, pre-conditioning, vitamin E, electrical stimulation and tenderness, but that work remains to be done before USDA releases requirements for antibiotic, breed, free range, grass fed, hormone and aged meat. The idea of standardizing such marketing claims for these "credence attributes" is excellent, and it is reasonable to expect that the AMS-USDA Certification and Process Verification Programs would be used extensively by those in the livestock, poultry and meat industries. This standardization of claims allows for authenticity management, against a given standard, and assures consistency in product labeling claims.

16. Traceability to isolate the source and extent of quality control and food safety problems

Cross (1998) said (a) IAID and traceback will be driven by both governments and customers; (b) the "driver" for IAID and traceback is food safety; (c) in countries like the UK, where consumer confidence in meat safety is low because of BSE, IAID and traceback is viewed as a means of recapturing consumer confidence; (d) IAID and traceback will replace the "Hormone Ban" as a means to limit access to EU markets; and (e) under the agreements made during the Uruguay Round of GATT, any country requiring that US producers provide IAID or traceback of a specific type/kind would be required to comply with those same requirements in their own country.

Accurate traceability effectively reduces risk exposure by enabling food producers to identify, isolate and correct the problem quickly and efficiently, so that the public health is protected and the economic fallout from such incidents can be minimized (Gledhill, 2002). Fordice (2004) says food safety and security relates to concern with ensuring that there is not physical, chemical or biological contamination of food products either accidentally or through some malicious act. To support this, the capability to monitor and track the production of food products and provide traceability has become a major issue for processors (Fordice, 2004).

In July 2004, John Hayes (McDonald's Corporation) announced (Reuters, 2004) that (a) McDonalds is aiming to have at least 10% of its US beef purchases traceable from farm to table by year's end; (b) the effort is to help reassure consumers, in the wake of BSE in the US, about food safety; (c) when an issue develops within 48 h we must get the message to the consumer that we can contain the problem, know where the animal came from and we are ready to deal with it; we think an animal ID program is essential to being able to do that; and (d) at some point in the not-so-distant future all of our animal products will be from farms with ID programs". Since then, there has been increasing pressure for beef traceability from supermarkets (Cross, 2004): (a) Wal-Mart (in August 2004) invited its five major beef suppliers to a strategy session at its headquarters to determine how best to achieve traceback of retail cuts to farm-of-origin (and, including birth dates) and (b) Costco (in August 2004) notified its beef and pork suppliers to prepare to do "Cut To Dirt" (retail package to farm-of-origin) traceability.

Traceback is perceived as a double-edged sword by some US livestock and poultry producers. The good edge is that it helps producers identify superior/inferior stock and obtain premiums for livestock or poultry of superior merit, while the bad edge is that it could be used to penalize producers for generating poor-quality products and that they could be held liable if their products, for example, contained harmful chemical residues. Souza-Monteiro and Caswell (2004) concluded that (a) the identification of sources of food hazards or the possible deliberate falsification of the information introduced into databases raises the question of liability; (b) liability implies that the source of a given hazard will be held responsible for the consequences of its actions but when it is impossible to identify correctly the source of hazards, it is difficult to hold agents accountable; and (c) a clear private benefit of traceability systems is the possibility of proving that a given firm was not respon-

sible or does not present a risk when safety issues arise. Saunders (2004a) says "Logic suggests that implementation of traceability in conjunction with Best Management Practices that reflect greater access to, and the use of, information concerning the quality and safety of final products downstream in the marketing chain from producers actually would reduce liability because it could then be demonstrated that producers were concerned about the quality and safety of their products, and had managed their portion of the food chain appropriately".

Though there is presently no use of the technology in the US, DNA fingerprinting can be used to maintain IAID from farm to fork. The Superquinn™ supermarket chain in Ireland uses the IdentiGEN DNA Traceback™ process to guarantee traceability in the beef production and distribution chain (Smith, 2004b). In Australia and New Zealand, systems are in commercial use that take blood or muscle samples from beef and lamb carcasses, respectively, which can, if needed, be used for DNA fingerprinting to provide matches with meat demonstrated later to have contained harmful chemical residues or to have been unsatisfactory in palatability (Smith, 2004b). No such system will suffice for tracing-back meat with microbiological problems (e.g., presence of *E. coli* O157:H7) to individual animals because too many opportunities exist for commingling and cross-contamination. And, DNA fingerprinting would not be useful for identifying sources of BSE (or nvCJD) infections because the incubation times (from consumption of BSE-infected feed or food, to development of BSE in cattle or nvCJD in humans, respectively) is much too long (i.e., several years).

Smith, Belk, et al. (2000) discussed traceback capability as being important relative to food safety citing quotations from then-prominent industry or government spokespersons as saying: (a) product traceability would help minimize potential danger of meatborne pathogens to the restaurant industry, (b) traceback to the birth of the animal would be beneficial in reducing the threat of meatborne pathogen occurrence in the meat/poultry purveying sector, (c) a traceback mechanism is needed to track tainted beef from the grocery store back to the farm, and (d) consumer groups would like to start to build a better database on traceback and assure that recall authority and traceback (relative to food-poisoning organisms) are under government authority. But, Smith, Belk, et al. (2000) continued by saying that, for meatborne pathogens, cross-contamination is so likely that tracking them back to individual farms, ranches, and/or individual animals is not possible. Golan et al. (2005) reported that (1) one area where industry has no incentive to create traceability systems is for tracking food once it has been sold and consumed, (2) no firm has an incentive to monitor the health of the nation's consumers in order to speed the detection of unsafe product, (3) Government-supplied systems for monitoring the incidence of foodborne illness, such as FoodNet and PulseNet, are one option for helping close this gap in the food system's traceability network. Foodborne illness surveillance systems increase the capability of the entire food-supply chain to respond to food safety problems before they grow and affect more consumers.

Traceability for chemical residues can be important. Smith (2004b) said "if a carcass is found to contain violative residues of animal drugs, environmental contaminants or pesticides, the best means for preventing recurrence of the problem is to use IAID or AGID to identify the animal(s) involved and to identify the cause/source of the problem". Smith, Roeber, et al. (2000) reported that (a) Gary Smith (Colorado State University) said "It seems obvious that if cattle producers, who do not sell cows and bulls directly (on-the-rail) to the packer, are to bear responsibility for not properly managing, monitoring and marketing cattle, there must be a means or mechanism for identifying those who produced diseased animals. Such a system could be as sophisticated as requiring electronic, individual-animal identification devices (EIDs), as routine as using plastic or metal ear tags, or as simple as the tail tags used in Australia", while (b) Robert Brewer (FSIS-USDA) said "There is no doubt that the biggest need, to better manage market (cull or salvage) cows and bulls, is the implementation of a universal, foolproof IAID system" (National Cattlemen's Beef Association, 1999). McKean (2001) said "Technologies exist to maintain the identity of animals and animal products from birth to consumption. Public and private groups should avail themselves of these opportunities to improve public health and quality parameters for animals and animal products, or be prepared to have their market opportunities limited". Marchant (2002) said "In a consumer-driven market, those who fail to meet the increasing demands for food safety and quality run the risk of being marginalized in the marketplace".

17. Traceability to minimize product recalls and make crisis management protocols more effective

During fiscal year 2004, there were 47 recalls involving 2.7 million pounds of meat/poultry products (Chilton, 2004); 60% of those recalls resulted from pathogen (*Listeria monocytogenes*, *E. coli* O157:H7 and *Salmonella* spp.) adulteration while the other 40% resulted from labeling/misbranding, undercooking, foreign material or illegal imports. According to Chilton (2004): (1) Recalls are complex initiatives built upon a foundation of bad news, but companies that successfully manage a recall can turn bad news good by effectively managing the many facets of a crisis. (2) Every company should have a crisis management program that defines

the actions to be taken in the event of a recall; key elements of crisis management include traceability and lot coding procedures, forms to track recall information and mock recall procedures. (3) Companies should be able to track at least 98% of the selected lot within a 4 hour period. (4) Mock recalls should be conducted at least twice per year to test the traceability system to ensure that raw materials can be tracked, as well as packaging materials and finished products to the first point of distribution. (5) Some recalls have put meat and poultry companies out of business but most end up with stronger food safety programs; if a company is adequately prepared, and manages the recall process in the right manner, it should survive and ultimately thrive with solidified customer and regulatory relationships.

Faster, more thorough and precise food traceability can lessen the impact of a product recall by enabling the producer to quickly pinpoint where in the supply chain the problem originated and implement an appropriate remedy (Gledhill, 2002). Use of traceability systems have helped meat and poultry packers and processors isolate and locate the products associated with potential public health concerns regarding contamination with *E. coli* O157:H7 and *Listeria monocytogenes*, and, more recently, have helped facilitate trace-out, trace-back and trace-forward of livestock, by-products and meat associated with the BSE incident in the state of Washington. Use of such traceability systems minimizes the distribution of potentially unsafe products which also minimizes the potential for bad publicity, liability and recalls (Golan et al., 2004).

Gledhill (2002) discussed "meat traceability in action" and said (a) levels of product traceability that exist within the meat, poultry and fish industries vary enormously from country to country, and from company to company; (b) different levels of traceability are required for different animal types; basically, the larger the animal, the more precise the tracking required; (c) many meat processors trace back to the day of slaughter and from there can derive where the animals originated, but this approach means that if there is a recall, too much meat has to be called back because the root cause cannot be identified more precisely; and (d) with "end-to-end traceability", which is far more effective, the producer can save significant time and costs by pinpointing exactly which meat, and how much, needs to be recalled.

Maddock and Allen (2005) said a product recall can be both traumatic and costly for meat processors; worse, if improperly handled, it can send a company's fortunes plummeting, sometimes for good. They described two general types of causes of recalls, those due to risks inherent in meat processing (e.g., pathogens, foreign objects) and those due to mismanagement (e.g., failure to declare potential allergens on a product label) or poor quality control (e.g., undercooking or under processing of a product), and the tracing/tracing of such product in an expeditious manner (Maddock & Allen, 2005).

In the US livestock, poultry and meat industries, life-cycle traceability has seldom been required to protect consumers; instead, essentially all recalls involve the packer, processor, wholesaler, distribution system and/or retailer. Most US packers and processors of livestock and poultry developed and refined recall procedures and crisis management protocols as a part of development of Hazard Analysis Critical Control Point programs during the last decade. In large part, development of traceability systems from packer/processor to the backrooms of supermarkets, foodservice outlets and restaurants is complete. Of concern now is whether or not it is, or will become, necessary to extend traceability systems backward to farms, ranches, finishing facilities, and whether the "driver" for such "life-cycle traceability" will be the government, packers, processors, wholesalers, retailers…or consumers.

18. A status report on worldwide cattle/beef traceability

Souza-Monteiro and Caswell (2004) concluded that: (1) Most beef exporting countries are adopting some kind of traceability system in response to mandatory systems introduced in such important importing countries for high-quality beef cuts as Japan and the EU; the exporters' main motivation is to maintain or increase their positions in international markets for beef. (2) Traceability systems are a way to assure that credible information on credence attributes, such as food safety, flows across agri-food marketing chains from farm to fork. (3) Traceability systems are developing at a different rate across trading partners; in many countries, traceability is being instituted first in the beef supply chain. (4) The EU and Japan are leading the trend toward adoption of mandatory traceability, to prevent or diminish risks to animal and human health, and they have the broadest, deepest, and most precise beef traceability systems. (5) Australia and Brazil, where the beef export market is important, plus Argentina and Canada have recently adopted mandatory traceability systems but their systems are less extensive than those of the EU or Japan. (6) The US has not adopted mandatory traceability systems, although several voluntary systems are operating and new systems are being developed. (7) The economic implications of mandatory and voluntary traceability systems will be especially prominent in the areas of animal and human health, international trade, and supply chain dynamics. (8) Countries that have already adopted traceability systems have positioned themselves to gain the economic benefits of such systems, either domestically or in export markets; the extent to which these benefits justify the costs of such systems and how benefits and costs will be distributed

remains to be fully analyzed. (9) Overall, it is clear that traceability will become an increasingly integral feature of markets for food products (Souza-Monteiro & Caswell, 2004). And, we might add, for livestock, poultry and meat.

References

Agnosco (2003). Technology description supporting: Food security analysis and global food traceability program. Mimeograph Report. The Rand Corporation, Washington, DC, pp. 1–10.

AMS-USDA (2001). United States standards for livestock and meat marketing claims. AMS-USDA, notice and request for comments. Docket No. LS-01-04. Available from http://www.ams.usda.gov/lsg/stand/claimcomment.htm.

AMS-USDA (2002a). 2002 Farm bill provisions. Subtitle D – country of origin labeling. Available from http://www.ams.usda.gov/cool/subtitled.htm.

AMS-USDA (2002b). 2002 Federal Register, Vol. 67, No. 225. Available from http://www.ams.usda.gov/cool/ls0216.htm.

AMS-USDA (2003). 2003 Federal Register, Vol. 68, No. 210. Available from http://www.ams.usda.gov/cool/ls0304.pdf.

AMS-USDA (2004). Specified product requirement: Beef export verification. ARC Procedure 1002 Quality Systems Assessment Program. Available from http://www.ams.usda.gov/lsg/arc/qsap.htm.

Anderson, P. (2004). Supermarket chain uses discount cards to inform customers of recalls. *Agweek*(January), 50.

APHIS-USDA (2004a). The National Animal Identification System (NAIS): Why animal identification? Why now? What first? Program Aid No. 1797 (pp. 1–14). Animal and Plant Health Inspection Service, US Department of Agriculture, Washington, DC.

APHIS-USDA (2004b). Premises identification: The first step toward A National Animal Identification System. Program Aid No. 1800 (pp. 1–14). Animal and Plant Health Inspection Service, US Department of Agriculture, Washington, DC.

Bailey, D. (2004). Benefits and costs associated with an animal identification system for cattle in the United States (pp. 1–11). Western Extension Marketing Committee, Utah State University, Logan, UT. WEMC FS #2-04 (Fall 2004).

Beef (2004). International consumers' perceptions of food safety today vs. 10 years ago (Citing a study by Ipsos News Center.). *Beef, 41*(3), 7.

Caspers, J. (2003). *USDA analysis confirms high costs no benefits for MCOOL* Press release (October 17, 2003). Des Moines, IA: National Pork Producers Council.

Chilton, J. (2004). Lessons learned: Laying the ground work for a successful recall. *Meat & Poultry*(December Issue), 48–52.

Clayton, P. (2002). International traceability. Prepared by US Meat Export Federation and Colorado State University and presented at the annual meeting of the US Meat Export Federation, Long Beach, CA, pp. 1–4.

Cross, H. R. (1998). Drivers for IAID and traceability. Presented at Cattlemen's College, National Cattlemen's Beef Association, Phoenix, AZ, pp. 1–8.

Cross, H. R. (2004). Increasing pressure for beef traceability – from supermarkets. Presented at Beef Quality Seminar, National Beef Packing Company, Kansas City, KS, pp. 1–4.

Darby, M. R., & Karni, E. (1973). Free competition and the optimal amount of fraud. *Journal of Law and Economics, 16*, 67–88.

Denis, A. H. (2004). Testimony of A.H. "Chico" Denis III on behalf of the American Sheep Industry Association. Presented to the Committee on Agriculture, US House of Representatives, Houston, TX, on March 5, 2004. Available from American Sheep Industry Association, Englewood, CO.

Drovers (2004). Mandatory COOL still alive. December Issue, p. 28.

Drovers Alert (2004). Any amount of traceability helps open export markets. December 9, p. 7.

Drovers Feeder Management (1999). Cattle identification: A voluntary national identification system, with the ability to maintain identification records on cattle from birth to rail should soon become reality. *Drovers Journal*(March Issue), 11–13.

Escort Memory Systems (2004). Escort Memory Systems, Fast Track™, RFID. Available from http://www.ems-rfid.com/contactus.html.

Feder, B. J. (2004). Wal-Mart edict on radio tags hits snag. The New York Times, The Denver Post, December 28, p. 6C.

Feedstuffs (2000). National animal identification needed in three years, August 8, p. 3.

Food Production Daily (2004). Don't worry about RFID deadline, says expert, November 11. Available from www.foodproductiondaily.com.

Food Production Daily (2005). RFID revolution inevitable as IT spending set to increase, January 25. Available from www.foodproductiondaily.com.

Food Safety Network (2004). Microchip to track Canadian livestock right to consumer's plate. *The Edmonton Journal*, November 7. Available from FSNET-L@listserv.uoguelph.ca.

Food System Insider (2004). Beef – it's what's for dinner, October 15, p. 7.

Fordice, R. (2004). Under control. *Meat Processing*(November Issue), 34–40.

Fraley, J. (2004). *National Animal Identification System (NAIS): FAQ Sheet* (pp. 1–6). Chicago, IL: Illinois Farm Bureau.

Gledhill, J. (2002). Tracing the line: Using information technology to reduce costs while meeting industry requirements. *Food Processing*(March Issue), 48–57.

Golan, E., Krissoff, B., & Kuchler, F. (2005). Food traceability: One ingredient in a safe and efficient food supply. *Prepared Foods*(January Issue), 59–70.

Golan, E., Krissoff, B., Kuchler, F., Calvin, L., Nelson, K., & Price, G. (2004). Traceability in the US food supply: Economic theory and industry studies. Agricultural Economic Report Number 830, Economic Research Service, US Department of Agriculture, Washington, DC.

Hibbert, R. (2005). Food bioterrorism: Is the US food supply really vulnerable? *Meat Processing*(January Issue), 70.

Hillman, B., & Hammerschmidt, N. (2005). Q & A on animal ID: Keeping up with the evolving national system. *Drovers*(January Issue), 38–40.

Hisey, P. (2005). The trace race. *Meat Marketing & Technology*(January Issue), 60–67.

Hoffman, T. W., Roeber, D. L., Belk, K. E., LeValley, S. B., Scanga, J. A., Sofos, J. N., et al. (2004). Producing consumer products from sheep: The sheep safety and quality assurance program. Englewood, CO: American Sheep Industry Association/Fort Collins, CO: Colorado State University.

IdentiGEN (2004). Farm to fork traceability through DNA traceback. Mimeograph Report (pp. 1–3). IdentiGEN, Ltd., Dublin, Ireland.

Jenkins, C. (2003). HACCP further up the food chain. *Food Quality, 10*(3), 55–56.

Joy, D. (2004). COOL rules finally issued. *Food Processing*(November Issue), 15.

Lawrence, J. D. (2005). National animal identification: Background and basics for cattle producers. *Beef Questions & Answers, 10*(1), 4–5 (Montana State University, Bozeman, MT).

Linderoth, S. (2005). How to assess individual animal ID technology: Five things to check before you buy. *Dairy Herd Management*(January Issue), 32–37. Available from www.beefstockerusa.org/rfid/grid.htm.

Loureiro, M. L., & Umberger, W. J. (2004). Estimating consumer willingness to pay for country-of-origin labeling. *Journal Agriculture Resource Economics, 28*(2), 287–301.

Maddock, R., & Allen, D. (2005). Practice makes perfect. *Meat Marketing & Technology* (January Issue), 70–73.

Marchant, J. (2002). *Secure animal identification and source verification* (pp. 1–27). Fort Collins, CO: Optibrand Ltd., LLC.

Marshall, T. (2004). USDA moves on a national animal identification system. *Cow-Calf Weekly* (April 30), 5–6.

McKean, J. D. (2001). The importance of traceability for public health and consumer protection. *Review Science Technology Office Int. Epiz., 20*(2), 363–371.

Meat Marketing and Technology (2004). Animal ID: Are we there yet? (November Issue), p. 46.

Meatnews (2003). Major US pork processor is compliant with upcoming country of origin labeling. Available from harris@wattpub.demon.co.uk.

Meghen, C. (2000). DNA traceability of meat (pp. 1–8). Presented at a Meat and Livestock Commission Meeting, London, UK.

Miller, M. (2004a). Laying the foundation. *Pork*(November Issue), 18–19.

Miller, M. (2004b). Just the beginning. *Pork*(December Issue), 5.

Miller, M. (2005). What lies ahead? *Pork*(January Issue), 5.

National Cattlemen's Beef Association (1999). Improving the consistency and competitiveness of market cow and bull beef & increasing the value of market cows and bulls. Final Report to NCBA by the Department of Animal Sciences, Colorado State University, Fort Collins, CO.

National Provisioner (2004). RFID solution. December Issue, p. 73.

Neff, J. (2005). Track & trace. *Food Processing*(January Issue), 26–30.

NIAA (2004). Animal ID: NIAA member survey registers top animal ID concerns. National Institute for Animal Agriculture. Available from www.animalagriculture.org/survey/NAIS.htm.

Nortje, G. (2002). Animal identification – the best way forward – animal ID is part of a traceability system. Mimeograph Report (pp. 1–37). Presented at the Food Safety Summit and National Meat Association Annual Convention, Washington, DC/Las Vegas, NV.

Ohio Department of Agriculture (2004). Animal Identification: Swine. Available from http://www.ohiolivestock.org/images/AnimalID-SwineFactSheet.pdf.

Paige, J. C. (2003). Animal traceability – identification (pp. 1–6). Presented at the Federation of Animal Science Societies Symposium, Rockville, MD.

Plain, R., & Grimes, G. (2003). *Benefits of COOL to the cattle industry*. Columbia, MO: Department of Agricultural Economics, University of Missouri, http://agebb.missouri.edu/mkt/cool.htm.

Pork (2002). Interim country-of-origin labeling guidelines issued. November Issue, p. 13.

Reagan, J., Bellinger, G., McAdams, J., Clayton, P., Genho, P., & Richmond, B. (2003). Problems associated with implementation of COOL. Report of Cluster Group 3. In *Proceedings of the International Livestock Congress – 2003*, Houston, TX (pp. 25–26).

Reuters (2001). Farm sector seen vulnerable to bioterrorism. *Reuters Online*(October 18).

Reuters (2004). McDonalds sets 10% beef traceability goal for 2004. *Reuters Online*(July 2).

Salant, J. D. (2003). *Mad cow appears in the US* (p. 1). The Coloradoan: The Associated Press.

Saunders, L. (2004a). Traceability and the brand promise (pp. 1–l6). Presented at Kansas State University. Available from http://www.imiglobal.com.

Saunders, L. (2004b). Livestock identification and traceability: Software, EID and USAIP (pp. 1–45). Presented at the Gallagher National Sales Conference. Available from http://www.imiglobal.com.

Saunders, L. (2004c). USDA data service provider (pp. 1–16). Presented to a Japanese trade team. Available from http://www.imiglobal.com.

Saunders, L. (2004d). Consumer, retail, foodservice and export market: Expectations (pp. 1–10). Presented to the North American Limousin Visions Symposium. Available from http://www.imiglobal.com.

Saunders, L. (2005). National's proposed GSA addition to include age verification for Japan (pp. 1–16). Presented to a Japanese trade team. Available from http://www.imiglobal.com.

Shapiro, S. (2002). We're all affected: An overview of the food protection provisions of the new bioterrorism law. *Food Quality, 9*(5), 20–21.

Sheep & Goat Health Report (2004). Sheep industry working group mulling US animal ID plan. Bowling Green, KY: National Institute for Animal Agriculture.

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2003). *Designing and managing the supply chain*. New York, NY: McGraw-Hill Irwin.

Sitz, B. M., Calkins, C. R., Umberger, W. J., & Feuz, D. M. (2004). Consumer preference and value of beef with country-of-origin labeling. 2004 Beef Cattle Report (pp. 81–82). Lincoln, NE: University of Nebraska.

Smith, G. C. (1999a). Meeting the challenge…what can you do? (pp. 1–12). Presented at the Cattlemen's College of the National Cattlemen's Beef Association Midyear Conference, Denver, CO.

Smith, G. C. (1999b). Providing assurances of quality, consistency, safety and a caring attitude to domestic and international consumers of US beef, pork and lamb (pp. 1–8). Presented at the 12th World Meat Congress, Dublin, Ireland.

Smith, G. C. (1999c). Traceability: Source-verification, production practice-verification and USDA process-verification (pp. 1–11). Presented at the Expo Prado '99, Montevideo, Uruguay.

Smith, G. C. (2000). Assuring compliance in branded-beef alliances: Source-verification, production practice-verification and USDA process-verification (pp. 1–16). Presented at the Harris Ranch Partnership For Quality Beef Alliance Seminar, Coalinga, CA.

Smith, G. C. (2001). What are we doing to prevent entry of potentially catastrophic foreign animal diseases into the USA. In *Proceedings of the range beef cow symposium*, Casper, WY (Vol. XVII, pp. 218–226).

Smith, G. C. (2004a). Testimony of G.C. Smith on behalf of the International Stockmen's Educational Foundation. Presented to the Committee on Agriculture, US House of Representatives (Houston, TX) on March 5, 2004. Available from International Stockmen's Educational Foundation, Fort Worth, TX.

Smith, G. C. (2004b). Tracing US progress on individual ID. Mimeograph Report (pp. 1–16). In *Feedback, Meat & Livestock Journal* (November/December 2004 Issue, p. 11). Meat & Livestock Australia, Sydney, Australia.

Smith, G. C. (2004c). Traceability in the pork industry (pp. 1–8). Presented at the National Swine Symposium, Las Vegas, NV.

Smith, G. C. (2005). Field Report – US Embassy Seminars in Korea and China (January 2005). Report to the US Meat Export Federation (Denver, CO) (pp. 1–10). Department of Animal Sciences, Colorado State University, Fort Collins, CO.

Smith, G. C., Belk, K. E., Scanga, J. A., Sofos, J. N., & Tatum, J. D. (2000). Traceback, traceability and source verification in the US beef industry (pp. 1–12). Presented at the XXI World Buiatrics Congress, Punta del Este, Uruguay.

Smith, G. C., & Morgan, J. B. (1999). Understanding today's customers and marketing to their needs (pp. 1–27). Presented at the Wakefern Food Corporation, Fresh Solutions Seminar, Edison, NJ.

Smith, G. C., Roeber, D. L., Belk, K. E., Tatum, J. D., Field, T. G., & Brewer, R. L. (2000). Incidence of condemnations of market cow and bull, cattle, carcasses and offal nationally, and implications of a

national individual-animal identification program for minimizing these losses. In *Improving the consistency and competitiveness of market cow and bull beef; and improving the value of market cows and bulls* – The Final Report of the National Market Cow and Bull Beef Quality Audit – 1999 (pp. 133–138). Englewood, CO: National Cattlemen's Beef Association.

Smith, G. C., Savell, J. W., Morgan, J. B., & Montgomery, T. H. (2000). *Executive Summary of the 2000 National Beef Quality Audit*. Englewood, CO: National Cattlemen's Beef Association.

Souza-Monteiro, D. M., & Caswell, J. A. (2004). *The economics of implementing traceability in beef supply chains: Trends in major producing and trading countries*. Amherst: Department of Resource Economics, University of Massachusetts, http://www.umass.edu/resec/workingpapers.htm.

Sparks (2002). *Food traceability: Standards and systems for tracing and tracking food and agri-products*. Memphis, TN: Sparks Companies, Inc..

Steinsträter, M., & Jensen, A. (2001). Complete traceability in the cutting up of beef. *Fleischwirtschaft International*(2), 52–54.

Talbot, D. (2004). Where's the beef from? *Technology Review, 107*(5), 48–58.

Umberger, W. J. (2004). *The National Animal Identification System and Country-of-Origin Labeling: How are they related* (pp. 1–11). Fort Collins, CO: Western Extension Marketing Committee, Colorado State University, WEMC FS #4-04 (Fall 2004).

Umberger, W. J., Feuz, D. M., Calkins, C. R., & Sitz, B. M. (2003a). Country-of-origin labeling of beef products: US consumers' perceptions. *Journal Food Distribution Research, 34*(3), 103–116.

Umberger, W. J., Mark, D. R., & Feuz, D. M. (2003b). Mandatory country of origin labeling: The ongoing COOL debate continues in Kearney. Available from http://agecon.unl.edu/mark/Papers/CH_5-21-03.pdf.

USDA/AASRP/NIAA (2004). A guide to the national scrapie eradication program for veterinarians. Riverdale, MD: United States Department of Agriculture/Bowling Green, KY: American Association of Small Ruminant Practitioners, National Institute for Animal Agriculture.

US Government Accounting Office (2003). Country-of-origin labeling, opportunities for USDA and industry to implement challenging aspects of the new law, GAO-03-780. Available from: http://www.gao.gov/new.items/d03780.pdf.

Weimers, J. F. (2000). Developing a national farm animal identification system (pp. 1–20). Mimeograph Report by the National Animal Identification Coordinator, Veterinary Services, Animal and Plant Health Inspection Services, US Department of Agriculture, Washington, DC.