

# TRACEBACK, TRACEABILITY AND SOURCE VERIFICATION IN THE U.S. BEEF INDUSTRY

G.C. Smith, K.E. Belk, J.A. Scanga, J.N. Sofos and J.D Tatum

Colorado State University, Fort Collins, Colorado, USA

## ABSTRACT

"Traceback," "traceability" and "source verification" refer to the ability to identify origin of animals or meat as far back in the production sequence as necessary to ascertain ownership, identify parentage, improve palatability, assure safety and determine compliance in "branded beef" programs. Hide branding, ear tagging (metal, plastic, electronic), tail tagging and retina scanning allow Individual Animal Identification (IAID) up to slaughter. IAID is maintained through slaughter by animal/carcass tagging or trolley tracking. IAID is maintained through fabricating/boning by keeping units separated, tagging or DNA fingerprinting in small, medium or large plants, respectively. DNA fingerprinting can maintain IAID of product through retail. In the USA, Merial, Allflex and AgInfoLink have formed "Beef Results Network" using electronic ear tag IAID. "USA Cattle Identification System" maintains IAID using metal, plastic or electronic ear tags. "Optibranding" assures IAID using retina scanning. Those three programs involve voluntary, birth-to-carcass IAID. Allflex, Texas Beef Council and Texas A&M University followed beef through supermarkets using bar-coded plastic tags for IAID. Animal Group Identification (AGID) is used for "branded beef," and beef from "alliances" or "supply chains" for verification of source, production-practices and USDA-processes, to assure palatability and to ensure chemical and microbiological food safety. If a claim is made about meat in the EU, groups--not individual animals--must be traceable, and identity must be established by traceback for all cuts except cured or fresh minced meat. Because of the importance of export markets, the USA beef industry maintains an open mind on issues related to IAID, AGID and traceback.

## DEFINITION

"Traceback," "traceability," "source verification"—all three terms are being used, globally, to refer to the ability to identify animals according to their origin, as far back in the production sequence as is necessary to accomplish the intended purpose (usually for meat safety—chemical or biological—reasons). Acceptance of the concept of being able to traceback animals, to the farm or ranch level, is mixed among USA cattle producers because it can be a double-edged sword—it can bring reward or punishment (Smith, 1999a).

Traceability is important (Smith, 1999b): (a) For ascertaining ownership (to whom does the animal belong?). (b) In identifying parentage (who were its sire and dam?). (c) For

---

Presented at the XXI World Buiatrics Congress, on December 5, 2000 in Punta del Este, Uruguay.

improving palatability (which animal produced this tough steak?). (d) For assuring food safety (which animal carried *E. coli* O157:H7?). (e) For determining compliance in branded-beef programs (is the process under control?).

## DEMAND DRIVERS

At the World Meat Congress (Dublin, Ireland; May, 1999), representatives of the USA, the EU, Argentina, Australia and New Zealand discussed "Demand Drivers For Beef" (grouped as Economic, Non-Economic, Ethical and Ecological concerns) in their respective countries (Smith, 2000b). All five countries identified, as important Demand Drivers, the two Economic concerns (cost; price/value) and three of the four Non-Economic concerns (food safety; eating quality; diet/health/nutrition). Unique to the USA and the EU was the Non-Economic concern, convenience. The EU and New Zealand were the only countries that identified the Ethical concern, animal welfare, and the Ecological concern, environment, as Demand Drivers; the EU alone considered the Ecological concern, food from genetically modified organisms (GMOs), to be a Demand Driver (Smith, 2000b).

Some customers show their disapproval for certain beef entities or companies by not buying their products if they: (A) Cannot "traceback" products to the farm, ranch or feedlot of origin. (B) Befoul the environment. (C) Tolerate the mishandling or mistreatment of cattle (Smith, 2000c). Worldwide trends toward traceback and animal welfare include: (1) Passport identification in the EU. (2) Mandatory individual slaughter cattle identification in Canada. (3) Emphasis on animal welfare by a supermarket chain in the UK. (4) Emphasis on animal welfare by McDonald's Corporation worldwide (Smith, 2000c).

The USA beef industry is converting from being "production-driven" to becoming "consumer-driven" (Smith, 1999d). In a consumer-driven beef industry, consumers eating in the home or in a food-service establishment indicate preferences and express opinions about the cooked endproduct; those preferences/opinions then flow backward through the production sequence to the meat market or food-service establishment operators and through purveyors, packers, cattle feeders, stockers/backgrounders and cow/calf operators to seedstock producers (Smith, 2000c).

Smith (2000a) said that the guarantee that must be provided to consumers of USA beef is as follows: "Assuring that domestic and international consumers receive bacteriologically and chemically safe, healthful, high quality and consistently palatable beef that was produced without compromising the environment or the animals' welfare." The part of the guarantee that deals with "Assuring...that the beef was produced without compromising the environment or the animal's welfare" will necessitate: (a) Traceback to the farm or ranch. (b) Individual animal identification. (c) Producer/packer concern about animal welfare. (d) Producer concern for the environment.

## IMPETUS FOR INDIVIDUAL ANIMAL IDENTIFICATION AND TRACEBACK

Cross (1998) said: (1) Individual animal identification (IAID) and traceback will be driven by both governments and customers. (2) The "Driver" for IAID and traceback is food safety. (3) 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. (4) IAID and traceback will replace the "Hormone Ban" as a means to limit access to EU markets. (5) Under the agreements made during the Uruguay Round of GATT, any country requiring that USA producers provide IAID or traceback of a specific type/kind would be required to comply with those same requirements in their country.

## TRACEBACK FOR IMPROVING BEEF PALATABILITY

Traceability is being capitalized upon as a means for improving beef palatability in the USA (Smith, 2000a). Research has shown that assurance of adequate or exemplary palatability of beef can be dramatically improved through genetic selection for "good" palatability or against "bad" palatability in product from the progeny of specific sires and dams. In such cases, traceback from the carcass to the parents of the animal that produced the carcass is sufficient; there is no need to follow wholesale or retail cuts to the enduser because a small sample of the wholesale rib or shortloin can be removed from the carcass and tested for flavor, juiciness and tenderness (Smith, 2000a). It is important to identify sires and dams of cattle likely to produce unpalatable beef; Savell and Griffin (1988) determined that 542 individual consumers are impacted by retail steaks and roasts from a single beef carcass.

## TRACEBACK FOR IMPROVING BEEF SAFETY

Traceback capability is important relative to food safety; Smith (1999b) posed four questions regarding such issues and answered them using quotations from leading USA industry group or government representatives. These were: (1) What do cattle producers need to do, about meatborne pathogens, for the restaurant sector? "Ten things, one of which is assure product traceability." (Chet England, National Council of Chain Restaurants). (2) What do cattle producers need to do, about meatborne pathogens, for the purveying sector? "Four things, one of which is traceback to the birth of their animals." (Marvin Walter, North American Meat Processors). (3) What changes in recall policy are being considered by USDA? "A traceback mechanism to track tainted beef from the grocery store back to the farm." (Thomas Billy, Food Safety and Inspection Service, USDA). (4) What would consumer groups like to do relative to food-poisoning organisms? "Start to build a better database on traceback and assure that recall authority and traceback are under government authority." (Nancy Donley, Safe Tables Our Priority).

Traceability can be important for assuring meat safety in the USA. When beef is found to contain violative residues of animal drugs, environmental contaminants or pesticides, or meatborne pathogens, the best means for preventing recurrence of the problem is to

identify the animal(s) involved and to identify the cause/source of the problem (Smith, 2000c). If residues or pathogens are detected on/in animals or carcasses, IAID is easily accomplished; if residues or pathogens are detected on/in meat (especially ground meat), IAID is exceedingly difficult and possible only by use of auto-antibody analysis or DNA fingerprinting and even then, for meatborne pathogens, cross-contamination of the meat is so likely that IAID is not possible.

## TRACEBACK FOR BRANDED-BEEF PROGRAMS

Traceback is important for determining compliance in branded-beef programs in the USA. In branded-beef programs requiring source-verification, production practice-verification and/or USDA process-verification, IAID can be used from birth to carcass grading but not beyond, unless: (a) very small quantities of cattle/carcasses/beef are involved, (b) complete breaks (stop, cleanup, re-start) in a shift occur, or (c) enough product is involved to allow complete-shift fabrication and processing (Smith and Morgan, 1999). Complete-shift fabrication and processing allows sequentially numbered cattle, carcasses, cuts, trimmings batches, boxes, lugs and combo-bins to be used to maintain animal group identification (AGID) but not individual animal identification (IAID). And, if the shift is the first in the morning, mixing of product is minimized and microbiological integrity of product is protected (Smith and Morgan, 1999).

## IS TRACEABILITY POSSIBLE IN THE USA?

Is complete traceability, from animal to enduser, possible in the USA? It is if fabrication and processing are slow enough. However, new or reconfigured facilities, numerous additional workers, much more equipment (especially grinders), many more production breaks (one per animal) and much more frequent clothes-changes, wash-downs, air-changes and cleanups would be required; costs to fabricate would increase dramatically...perhaps tenfold (Smith, 1999b). It would be possible now to maintain IAID for primal and subprimal cuts (using bar-coded tags on each piece) while fabricating at about 70 to 80% of present speed (with many more people on the line, just to maintain identity); but, it would be essentially impossible to maintain IAID for bones and trimmings (Smith, 1999b). Clayton and Belk (1998) determined the number of cattle contributing muscle and/or fat tissue to a single patty, concluding that in a single 4-ounce ground beef patty the fewest number of animals, on average, that contributed tissue to a patty was 55 and the greatest number, on average, was 1,082.

## WILL USA CONSUMERS PAY FOR SOURCE-VERIFICATION?

Is there evidence that USA consumers will pay for source-verified production, palatability or safety? Smith (2000c) documented four such pieces of evidence: (1) "Texas First" Traceback—Animals, carcasses and middle-meats were followed through to supermarkets. Consumers will pay 4 cents to 10 cents more per pound for source-verification (Texas A&M University). (2) Supermarket Customers—A major retail

supermarket chain reported it could sell "genetically-defined, source-verified" beef for 30 cents to 80 cents more per pound than U.S. Choice beef (Harris-Teeter Supermarkets). (3) Supermarket Customers—A research field study determined that 40% of shoppers would pay 50 cents more per pound for "Guaranteed-Tender U.S. Select Beef" (National Cattlemen's Beef Association). (4) Consumer Survey—Respondents said they would pay 29 cents to 34 cents more per pound for hot-water rinsed beef or steam-pasteurized beef guaranteed to be 90%-free or 99%-free, respectively, of *E. coli* (Kansas State University).

#### HOW WILL TRACEBACK BE ACCOMPLISHED IN THE USA?

Traceback can be accomplished (Smith, 1999b) by: (I) Horn branding, hide branding, ear tagging (metal, plastic, electronic), retina scanning (Optibranding™) or tail tagging, all of which work for individual animal identification (IAID) up to the point of slaughter, but IAID is lost as the head and hide are removed unless systems identified in part II, below, are employed. (II) IAID can be maintained through slaughtering/dressing by use of sequence-in-slaughter order, carcass tagging or trolley-tracking. (III) IAID can be maintained through fabricating/boning, easily, in small, low-speed operations and, with great difficulty, in average size and/or average-speed operations but is, essentially impossible, in large, high-speed operations.

Western Livestock Journal (1998) reported that for cattlemen who seek information on cattle, carcasses or cuts, electronic ear tags work best because transponder readers exist at packing plants, producers and packers can see them and they are reasonable in cost (\$2 to \$6). Other means for individual animal identification (IAID) include; (1) plastic or metal tags, (2) under-the-skin implants (like those manufactured by Destron/IDI, Boulder, Colorado), (3) ceramic boluses, (4) DNA profiling, (5) antibody profiling, and (6) retina scanning. Of these, though, only DNA profiling and antibody profiling can be used to identify cuts of meat from a specific animal, infallibly. Gigot (1998) reported that a company called Miragen (Irvine, California) was using a process called "Antibody Profiling" (AbP) to find Individual-Specific Antibodies (I-S Antibodies) that are present in body fluids and tissues to "fingerprint" individual animals, using this technology to detect autoantibodies and, unlike DNA, to identify animals—even discriminating between identical twins.

According to Wiemers (2000), the current primary driving forces behind the development of livestock identification systems in the USA are based on recognized public and private needs; they include: (a) disease control and eradication, (b) disease surveillance and monitoring, (c) emergency response to foreign animal diseases, (d) global trade, (e) livestock production efficiency, (f) consumer concerns over food safety, and (g) emergency management programs. Successful implementation of a national system in the USA will require a mutual understanding and reconciliation of public and private goals and objectives. The methods by which animals can be identified are visual and non-visual. Visual identification methods include ear tags, back tags, brands, tattoos, ear notches and color patterns; with these methods it is important to consider such things as read distance, permanence, cost, ease of reading, skill required to apply

the identifier correctly, degree of animal restraint needed, tamper resistance and ease of collection for traceback purposes (Wiemers, 2000). Non-visual identification methods include electronic identification (EID)—e.g., bar codes, two-dimensional symbology, radio frequency identification (RFID) and optimal character recognition (OCR)—and biometric identification—e.g., fingerprinting, voice recognition, face recognition, palm printing, vein printing, retina scanning, retina imaging, and iris scanning, of which only the last three have current application in livestock identification (Wiemers, 2000).

## TRACEBACK IN THE USA

Smith (1999b) reported that the National Cattlemen's Beef Association (NCBA) is moving forward on several fronts with regard to cattle and carcass identification. The NCBA initiatives include: (a) A voluntary, affordable, user-friendly, standardized system of electronic identification that conforms to beef safety guidelines should be encouraged to facilitate identity traceback between industry sectors and accelerate progress toward conformance of carcass quality standards (NCBA Carcass Quality Task Force, 1996). (b) An industry-wide standardized animal and carcass identification and data-transfer system should be developed (NCBA Market Resource Task Force, 1997). (c) NCBA adopted a voluntary national identification system (called USA, Cattle Identification System, or USA CIS) with the ability to maintain individual records on cattle from birth to rail (NCBA Annual Convention, 1999).

National Cattlemen's Beef Association, in February 1999, adopted a resolution to develop the USA CIS for purposes of: (1) Information sharing to facilitate value-based marketing, with source-verification, and (2) Source-verification to help the beef industry assure the safety of its products, restore consumer confidence in the safety of beef, and protect producers from litigation relating to food safety (Smith, 1999b). Because discussions of individual animal identification (IAID) and traceback always have triggered discussions of producer liability, USA CIS will keep names/addresses of owners stored separately from cattle data; information in the database will be provided to the government only under specific circumstances set by the USA CIS Board of Directors.

AgInfoLink uses EID tags, CattleCode™, and "Pony Express™ internet capabilities to accomplish IAID from birth through carcass grading for process-verification purposes, reducing production costs and increasing profit through individual management (Buchanan, 1998). Beef Business Bulletin (1999) reported that Merial, Allflex USA and AgInfoLink formed a "Beef Results Network" on July 20, 1999, with the goal of using individual animal management technology to help the beef industry increase productivity, quality and profit. The technology to be used includes use of individual animal electronic ear tags, a reader and a database in the producer's computer. In this way, records of an animals' performance from birth-to-slaughter can be maintained for \$2.75 for an AllFlex USA ear tag, \$1.50 enrollment fee, \$1,000 for an ear tag reader and no charge for the AgInfoLink software program. Use of "Beef Results Network" provides data that beef producers can manage to make herd improvements (Beef Business Bulletin, 1999).

Where is the USA on traceback? Smith (1999b) reported that: (1) Individual animal identification (IAID) is being used for genetic improvement. Data collection is performed by branded-beef programs, packer programs and association programs. (2) There are two programs—USA CIS and Beef Results Network that are voluntary and encompass birth-to-carcass. (3) Animal group identification (AGID) is being used for branded-beef, source-verification, production practice-verification and USDA process-verification with the intent of assuring palatability, assuring chemical beef safety and assuring microbiological beef safety. (4) Inasmuch as some USA export markets now, or will soon, have mandatory IAID or AGID for food safety purposes, the USA beef industry maintains an open mind on this issue (Smith, 1999b).

Cornett (1999) reported that, as of January 1, 2000, any beef or dairy animal sold interstate in the 15-member EU will be required to have birth-to-plate individual identification; every animal must have its identification tags (with a unique code) attached no later than 20 days after birth—and that identification code will follow it through a mandatory beef labeling system. According to EU Council Regulation 820.97, signed on April 21, 1999 in Luxembourg, every member state will be required to maintain a database which will keep records of all beef and dairy cattle and their movements within that country. In order to be sold, animals must have ear tags in each ear—with individual identification—and be accompanied by a “passport” that lists all ownership and health data (Cornett, 1999). “The way the trade laws read” said Wendy Radakovich (U.S. Meat Export Federation), “no country can impose rules on others that it doesn’t impose on itself; we don’t know how the EU will use these rules in the USA but since they lost the Hormone Ban we can guess they won’t be anxious to be cooperative” (Cornett, 1999).

Smith *et al.* (2000d) cites Dr. Robert L. Brewer (Food Safety and Inspection Service-USDA) as saying “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, individual animal identification (IAID) system. Although the USDA has been responsible for much of the delay in developing such a system, that is now being corrected and USDA will truly support development of a useful identification system.”

Smith *et al.* (2000d) said “It seems obvious that if cattle producers, who do not sell market 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. The most logical system by which animals harvested at packing plants can be linked to the producers who marketed them—given the distribution/dispersion (from site of sale, to site of harvest) of market cows and bulls that are sold on a liveweight basis (often several times before reaching a packer)—would be via a national animal identification program. 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. Whatever is used, responsibility and education would be achieved when correlation of harvest information, from animal-to-producer and

producer-to-animal, and among all intermediary owners, occurs nationally (Smith *et al.*, 2000).

## TRACEBACK IN THE EUROPEAN UNION

According to an article in Meat International (1999), as of January 1, 2000, EU Council Regulation 820/97 requires that all fresh and frozen beef carry verified information on the origin of the animal. And, in the United Kingdom, the "British Cattle Movement System" (BCMS) uses a "Computerized Tracing System" (CTS) based upon EU law which requires: (a) Tags in both ears of cattle within 30 days of birth. (b) A passport application form (with birth date, sex, breed, dam) filed within 15 days after ear tagging. (c) Issue of a passport after the data on the form is verified (usually in 1 day). (d) A page from the passport must be sent to BCMS whenever animals change premises (Meat International, 1999). Retailers can contact BCMS to obtain data on animals that produced beef on sale in their markets.

Bord Bia (1999) in Ireland has a Quality Assured Beef "Traceability" program with regulatory controls that begin on the farm. All cattle are officially identified at birth and this identification stays with the animal through all changes of ownership through slaughter which facilitates traceability of product from farm, through production, to final dispatch. Bord Bia, the Irish Food Board, operates a Beef Quality Assurance Scheme that has, since 1992, provided assurance to customers that the product has been produced in accordance with the rules of the scheme and highlights the high standards the product has attained (Bord Bia, 1999).

Accurate registration of livestock in the Netherlands is seen as the key to progress in cattle improvement; the cattle improvement structure in Holland, which was established by the Royal Dutch Cattle Syndicate (NRS) forms the basis of today's breeding (Farmers Guardian, 1999). Livestock farmers are obliged by compulsory legislation to register their newborn calves within three days of birth and all imported animals have to be registered within three days of importation. Farmers register births, purchases, sales, movements and deaths of calves with a voice response system; this creates a direct link for data communication from the farmer's telephone to the computer which is then directly connected with the NRS database (Farmers Guardian, 1999). Besides extensive checking of data inputted by the computer, additional quality checks are carried out in the field to ensure that no mistakes are made; farm visits are made unannounced to check the information and procedures, and to check if all animals are ear tagged and registered. If there is any doubt about the information provided, blood-typing or DNA testing is done to verify the pedigree (Farmers Guardian, 1999).

In Sweden, a license ("Licens") must be obtained for each market animal; the producer must sign an affidavit and submit it to the control office (Kontroll utfores) of the Sevriges Notkottproducenters Intresseforening attesting to the fact that good animal husbandry/animal welfare practices were followed, that they are free of *Salmonella* and that no antibiotics were administered to the animal (Smith, 1999b).

Traceability for assuring meat safety in Europe is possible. Smith (1999b) reported that if a carcass is fabricated as a single unit—all parts on a table originating from the same animal and all trimmings from that carcass ground in a single batch—IAID can be reasonably assured but is still not absolute unless; (a) Cross-contamination from previous animals, equipment, air and workers can unerringly be prevented in the fabrication area, and (b) If there is no possibility of contamination of the meat during distribution and retail handling. Finland, Belgium and France have mandatory traceback; most other EU countries have voluntary traceback. Throughout the EU there are strong nationalistic promotions to get people (through labeling) to eat only meat from their own country. During Beef Committee discussions at the World Meat Congress (Dublin, Ireland) in May 1999, the means by which meat is followed after slaughter was discussed; in the EU, if a claim is made about specific meat in the EU, groups—not individual animals—must be traceable, and identity must be established by traceback for steaks, roasts and stew meat but not for cured or fresh minced (ground) meat.

### TRACEBACK IN AUSTRALIA

ALEIS (Australian Livestock Electronic Identification System) uses a pellet which securely encloses a transponder (the transponder registers an individual member for each animal) inserted via the throat as early as three months of cattle age; the pellet (transponder) settles in the reticulum and stays with the animal for life. The ALEIS reader (with antenna) is placed on a squeeze-chute; as the animal moves through the squeeze-chute, the antenna activates the pellet (transponder) then the reader sends the number to the computer (equipped with “On Farm Software,” specially designed to allow automation of stock details and individual history records). Animalife I.D., the “Smartcap” Animal Identification And Data Collection System, is distributed by a company in Brisbane, Australia and is used in the ALEIS (Smith, 1999b).

Individual animal identification (IAID) in Australia, according to Polkinghorne (1999) and Watson (2000), can also be accomplished as follows: (1) Each individual animal is identified by use of a uniquely numbered ear tag through marketing to slaughter. (2) Bar-coded paper tags with numbers correlated with those of the original ear tag numbers maintain IAID from slaughtering through grading of the carcass. (3) As the carcass passes the grading stand, blotting paper is used to swipe the exposed ribeye (*longissimus dorsi*) muscle, and the bloody blotting-paper is inserted into a plastic (Whirl Pak) bag bearing an IAID bar-coded sticker. (4) Through fabrication, lot identity—actually, animal group identification (AGID)—is maintained via bar-coded stockers on boxes. (5) If beef, at retail, needs to be identified—because of a problem of bacteriological or chemical safety or of palatability—by individual animal, lot identity (as AGID) is used to identify all of the animals in that lot and the individual animal is identified by use of DNA fingerprinting. Lot units of cattle, in the Australian system, would consist of 100 to 200 animals; so, the problematic beef would be linked to a single animal (for chemical or palatability problems, but not for microbiological problems—because of cross-contamination) by DNA fingerprinting the beef and then systematically/sequentially fingerprinting the pieces of blotting paper from the animals in that lot until the culprit is found. Watson (2000) reported that the cost of a single DNA

fingerprint analysis was \$15 AUS but has now been reduced to \$10 AUS; so, presuming a lot size of 100 animals, the maximum cost to obtain an IAID match to a problematic beef sample would be \$1,010 (AUS).

#### TRACEBACK IN SOUTH AMERICA

Huerta (1999) contacted scientists in his own and two other South American countries to obtain updates/opinions on status of traceability, and reported that: (I) In Brazil: (a) The Brazilians can presently identify meat cuts with a lot number (AGID). (b) The Brazilians have promised the EU that they can accomplish total traceability (individual cuts with individual animal identification numbers) by mid-2000. (c) Professor Eduardo Felicio (Cidade University) said "I do not believe it will be possible to meet the EU deadline." (II) In Uruguay: Dr. Hector Lazaneo (Ministry of Husbandry and Fisheries) said "We are following European guidelines for traceability but have not reinforced them yet." (III) In Venezuela: Dr. Nelson Huerta (U.S. Meat Export Federation, Venezuela) said "We are not yet capable of assuring Traceability." (IV) In Chile and Argentina: Dr. Franz Rivas (Ministry of Agriculture and Husbandry, Venezuela) said "Programs are starting to be implemented in Chile and Argentina."

#### REFERENCES

- Agricultural Research. 1992. Food poisoning cases linked by DNA fingerprints. (October Issue) pages 6-7.
- Armstrong, H. 1999. Beef tracking: A high-tech challenge. Meat International. (August Issue) pages 28-34.
- Beef. 1989. Electronic cowboys. (October Issue) pages 31-35.
- Beef. 1998. Show me the passport: Britain unveils its new "Cattle Tracing System" for animal identification. (October Issue) pages 68-70.
- Beef Business Bulletin. 1999. Network tries to I.D. quality. (July 23 Issue) page 3. National Cattlemen's Beef Association, Englewood, Colorado, USA.
- Bjerklie, S. 1994. Keeping track. Meat & Poultry. (July Issue) page 13-17.
- Bord Bia. 1999. Traceability. The Irish Food Board. Dublin, Ireland.
- Buchanan, L. 1998. From steer to eternity. Inc. Tech 1:66-73.
- Clayton, R.P. and K.E. Belk. 1998. An analysis of the number of individual beef carcasses likely to contribute muscle and/or fat tissue to a single ground beef patty. Unpublished data based on analyses performed in four U.S. beef packing plants and six beef-grinding plants in the United States. ConAgra Red Meat Company and Colorado State University, Fort Collins, Colorado, USA.

- Cornett, S. 1999. EU pressure for mandatory ID. Beef Today (August Issue) page 34.
- Cross, H.R. 1998. Global concerns for individual animal identification and traceback. Mimeograph Report from Food Safety Net, Inc. (Portland, Maine, USA).
- Drovers Journal. 1999. Cattle identification: A voluntary national identification system, with the ability to maintain individual records on cattle from birth to rail, could soon become reality. Drovers Feeder Management (March Issue) page 11.
- Farmers Guardian. 1999. Key to improvement is accurate registration. (July 2 Issue) page 19.
- Gigot, B.J. 1998. The ultimate traceback. CALF News Cattle Feeder. (August Issue) pages 20-22.
- Huerta, Nelson. 1999. Personal communication. (Dr. Huerta is an employee of U.S. Meat Export Federation, Maricao, Venezuela).
- Meat International. 1999. International standard for beef labelling. (August Issue) pages 37-42.
- Polkinghorne, Rod. 1999. Personal communication. (Mr. Polkinghorne is an employee of Meat Standards Australia, Sydney).
- Savell, J.W. and D.B. Griffin. 1988. Consumers impacted by retail steaks and roasts from a single beef carcass. Unpublished data. Department of Animal Science, Texas A&M University, College Station, Texas, USA.
- Smith, G.C. 1999a. Providing Assurances Of Quality, Consistency, Safety And A Caring Attitude To Domestic And International Consumers Of U.S. Beef, Pork And Lamb. Presented at the 12<sup>th</sup> World Meat Congress (Dublin, Ireland) pages 1-8.
- Smith, G.C. 1999b. Traceability: Source-Verification, Production Practice-Verification And USDA Process-Verification. Presented at the EXPO PRADO '99 (Montevideo, Uruguay) pages 1-11.
- Smith, G.C. 1999c. Meeting The Challenge...What Can You Do? Presented at the Cattlemen's College of the National Cattlemen's Beef Association Midyear Conference (Denver, Colorado, USA) pages 1-12.
- Smith, G.C. 1999d. Building Beef Demand For Today And Tomorrow. Presented at the Annual AMI/FMI/NGA/NCC Meat And Poultry Marketing Conference (Anaheim, California, USA) pages 1-12.

Smith, G.C. and J.B. Morgan. 1999. Understanding Today's Customers And Marketing To Their Needs. Presented at the Wakefern Food Corporation, Fresh Solutions Seminar (Edison, New Jersey, USA) pages 1-27.

Smith, G.C. 2000a. Providing Assurances Of Quality, Safety, Consistency And A Caring Attitude To Consumers Of U.S. Beef. Presented at the Montana Nutrition Conference (Bozeman, Montana, USA) pages 1-21.

Smith, G.C. 2000b. Demand Drivers For Beef—Economic, Non-Economic, Ethical and Ecological Concerns Of Consumers. Presented at the Annual Meeting, Region V, American National CattleWomen's Association (Jackson Hole, Wyoming, USA) pages 1-23.

Smith, G.C. 2000c. Assuring Compliance In Branded-Beef Alliances: Source-Verification, Production Practice-Verification and USDA Process-Verification. Presented at the Harris Ranch Partnership For Quality Beef Alliance Seminar (Coalinga, California, USA) pages 1-16.

Smith, G.C., D.L. Roeber, K.E. Belk, J.D. Tatum, T.G. Field and R.L. Brewer. 2000d. 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. Pages 133-138. *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.* National Cattlemen's Beef Association, Englewood, Colorado, USA.

Watson, Ray. 2000. Personal communication. (Dr. Watson is a professor at Melbourne University and a consultant to Meat Standards Australia, Sydney).

Western Livestock Journal. 1998. Electronic ear tags surface as marker of choice for cattle. (September 7 Issue) page 17.

Wiemers, J.F. 2000. Developing a National Farm Animal Identification System: A call for state, federal and industry cooperation. Draft by the National Animal Identification Coordinator, United States Department of Agriculture, Animal and Plant Health Inspection Services, Veterinary Services, Washington, DC, USA.