# Traceability systems in the meat industry

G. H. SHACKELL

AgResearch Invermay, Private Bag 50034, Mosgiel, New Zealand

**ABSTRACT**

New Zealand is reliant upon maintaining export markets for the sale of a significant proportion of its meat and dairy production. Any loss of key overseas markets has significant implications for the national economy. Therefore, we are obliged to meet or stay ahead of market drivers. Increasingly, one of those drivers is product traceability for reasons of consumer confidence. While traceability systems have a relatively short history, they have traditionally been paper and/or electronic based. They are generally managed by parties with a vested interest, and their integrity is difficult to monitor.

Animal products have a unique identifier, DNA, that is tamper proof. There are a number of DNA-based traceability systems around the world that are being used in the meat industry. As well as direct tracing of a meat sample back to the animal, and ultimately to the property the animal was raised on, DNA technologies are also being used on-farm for testing meat quality traits and determining the animal's pedigree.

This paper describes some of the traceability options that are in use within the environment in which New Zealand is competing for trade.

**Keywords:** traceability; meat; DNA.

## INTRODUCTION

The New Zealand (NZ) economy relies heavily upon the export of meat and dairy products as a major income earner. As such, it is important that steps are taken to protect current markets, and to meet any new demands or technology requirements placed on food commodity trading. NZ has varying levels of exposure to market forces within the three major animal-based food sectors (see Table 1). Eighty five percent of our beef production is exported, but we only provide 7% of the world's export beef market. We export 80% of our total sheep meat production, which is a 51% share of the total world market. In exporting 95% of our total dairy production, we command 25% of the world's export dairy product trade. The domestic market is such a small proportion of our total production that even relatively small downward changes in our trading balance would leave us in an over-production situation.

**TABLE 1:** The percentage of New Zealand beef, sheep meat and dairy production* that is exported and the percentage of world trade that each commands.

| Market | Production exported | Share of World Market |
|---|---|---|
| **Beef** | 85% | 7% |
| **Mutton** | 80% | 51% |
| **Dairy** | 95% | 25% |

* *Beef and mutton data derived from the Annual Review of the New Zealand Sheep and Beef Industry. Dairy data sourced from http://www.fonterra.com and http://www.mdcdatum.org.uk*

Because of our reliance on export markets and maintaining market share, we are therefore obliged to keep pace with market-led technology requirements. Given the significance of our export markets it could in fact be argued that we should be leading the world in terms of technologies that give a marketing edge.

Traceability of meat and meat products is a major issue in the meat industry. Parts of Asia, Europe and the Americas now have mandatory Country of Origin Labelling (COOL). While this allows the origin of meat to be established it is not strictly a traceability tool. COOL can also be manipulated (Castaldo, 2003). There are different implications of COOL dependant on usage. In the European Union (EU), with its common borders, meat products may be processed in a different country from where the animal was raised and COOL helps to trace meat through the processing and marketing trail. When COOL was introduced in the United States of America (USA), it was expected to encourage consumers to purchase domestic rather than imported product. However, in the case of NZ lamb, COOL in fact became a brand which encouraged the consumer to purchase preferentially the NZ product (Clemens & Babcock, 2004).

Discerning markets or governments, that are fearful of food safety scares (e.g. the potential for transferring BSE to humans in the form of variant Cruetzfeld Jacobs disease; Smith *et al*, 2004), are increasingly indicating that traceability systems for individual animal-derived food products will be required now or in the near future. Various options are available, with paper or electronic systems being the most common. However, these systems implicitly rely on the consumer having trust in the system. An alternative is to exploit the unique DNA identifier that all animals carry. DNA cannot be tampered with and is unique to one animal unless genetically identical individuals have been created either naturally as

fraternal twins, or by artificial reproductive technologies.

**Paper-based traceability**

Paper-based meat traceability systems are in place throughout the world, including NZ. In their various guises, they may or may not include farm assurance programmes as well. Examples of systems that illustrate the information and assurance potentially available to the consumer are described below.

The **Graig Farm** Producer Group is a network of organic farmers in the United Kingdom (UK) advertising traceability of meat sold under their brand (http://www.graigfarm.co.uk). All livestock is sourced from within the Group, allowing a claimed knowledge of the origin of all animals. Each meat pack has a label explaining the breed, where the animal was reared, a little about the farm, and a website address where more information about the farm can be found. Traceability is achieved by using labels and barcodes on each carcass, applied when meat arrives from the abattoir and maintained as it passes through the various stages of processing. Graig Farm claims this is a unique system in the British Organic sector.

The **Waitrose** supermarket chain has a system that is typical of in-house traceability. A farm-assured production scheme ensures that beef sold in Waitrose supermarkets follows a dedicated supply chain, with animals going directly from accredited farms to specially approved abattoirs (http://www.waitrose.com). Pre-packed beef carries traceability information on the packaging, including where the animal was slaughtered, where the meat was cut and prepared, confirmation that the animal was born, reared and slaughtered in the UK, and a date code identifying the daily batch of animals. Although slaughterhouse and cutting plant licence numbers are not required for minced products (that are likely to contain a combination of animals), Waitrose claims full traceability for products where beef is used as an ingredient (for example, patties) by using the date and other codes.

**Canterbury Meat Packers** is a NZ processing company with an in-house traceability scheme for lamb, sheep, cattle and transportation. Their Certified Farm Assured programme makes accredited farmers accountable for meeting a set of best practice standards that include the correct use of animal health products, stringent presentation standards prior to slaughter and stock being transported only by accredited operators (http://www.cmp.co.nz). During processing each carcass receives a unique identifier to enable traceability back to the farm of origin. This scheme is promoted as ensuring that meat is produced in accordance with NZ's 'clean, green' image.

**Saitama Prefecture** in Japan operates an enhanced traceability system that builds on the mandatory national scheme and was described by Ozawa *et al.* (2005). By entering barcode information found on the packaging into a computer located at the meat display, the consumer can obtain information about the meat cut he or she is holding, at the point of sale. The system is specifically designed for Fukaya Wagyu beef and exploits the principle that the producer's willingness to be identified adds credence to the product.

**The Netherlands** operates a national two-part registration and tracing system for pigs and pig meat (http://www.hollandmeat.nl). The first part is an Identification and Registration (I & R) system that applies up to the slaughtering process. All Dutch pigs are registered and fitted with an ear-tag identifying the farm of origin. Lost ear-tags must be replaced immediately and all links in the chain are prohibited from receiving non-tagged or incorrectly tagged animals. Pigs leaving a farm for transport to the slaughterhouse are fitted with a slaughter tag. If more than 1% of a batch of pigs arriving at a slaughterhouse are without a slaughter tag the batch loses its status and all the pigs are downgraded. Transport of animals and the registration of vehicles are included in the system. All movements of pigs are reported to the I & R computer and details are double-checked against documents that accompany the animals during transportation. This database ensures that the origin of pigs can be quickly and efficiently identified and their movements traced. In the second half of the system, from the slaughtering process onwards, a system of strict channelling of animals and meat is enforced. Data can also be linked to make it possible to trace the health data of a particular batch of pigs.

**DNA-based traceability systems**

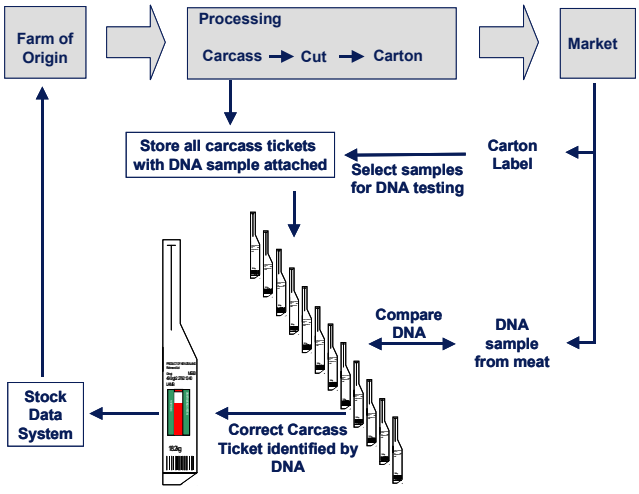
DNA-based systems operate differently to paper systems in that the identifier is present in every cell in the product and not attached to it at some point in the production chain. At any point in the distribution of the product, a small sample can be collected and the DNA profile used to trace back to an individual animal and blood or tissue samples collected from carcasses in a meat processing plant can be stored for the shelf-life of the product. As DNA profiling is outside the capabilities of meat processing plants, the actual tracing is usually done by an independent agency, which adds credence.

All meat industry DNA-based traceability systems follow similar pathways with most systems using tissue and/or blood samples from carcasses or live animals, or hair follicles from live animals. Prior to (or at the time of) slaughter, a blood or tissue sample is taken from each animal, or carcass, and held in storage. When a carcass enters the cutting room, each primal or packaged cut is identified in such a way that either the individual animal or the cohort that went through the slaughter facility at the same time can be identified. When a trace is required, a sample of the meat and/or the identifying packaging information, are conveyed to the facility that holds the DNA samples. The group of stored DNA samples that is likely to contain the sample from the carcass involved is selected and DNA profiles used to match unequivocally the sample to the carcass or animal that it originated from. For any DNA-based system to be effective, an auditable production trail

through the processing facility is essential and the processor must follow standard operating procedures that avoid contamination. Providing these conditions are met, a standardised and validated analytical procedure will match the DNA profiles of a carcass at slaughter to a meat sample in a packing carton. Some examples of DNA meat traceability systems are described below.

**easiTrace™** is a NZ system typical of DNA-based traceability (see Figure 1). A blood sample is collected on a tamper-evident label from the neck of each carcass prior to it entering the cutting room. Carcass tickets, with their attached DNA samples, are bulked and labelled with times and dates prior to being stored. After processing, meat cuts are packaged and labelled with date and time prior to shipping. When the need for a trace arises, a sample from the meat cut is forwarded to the laboratory and packing information is sent to the processor. The processor associates the packaging information back to a slaughter date and time, identifies the group of carcasses most likely to have contributed to the carton from which the sample originated, selects the appropriate carcass samples and sends them to the laboratory. DNA profiles from the 'most-likely' carcass tickets are compared with the DNA profile from the sample, and an exact match found. If a match cannot be confirmed within the group of animals specified, the 'most likely' group is expanded. Following a match, carcass ticket information is used to determine the supplier of the animal the carcass originated from. The easiTrace™ system uses microsatellite DNA markers and has been installed successfully in the sheep meat industry, and been shown to be effective in tracing meat samples back to the farm of origin (Shackell *et al.* 2001).

**FIGURE 1:** Diagrammatic representation of the pathways in the easi**Trace**™ DNA-based meat traceability system. (*Reproduced from Shackell et al 2001*)




**Eurofins-TAG©** is a beef traceability product of Eurofins, a bioanalytical company based in Belgium, with outlets in Europe, Asia, USA and South America (http://www.eurofins.com). It is described as a verification system for meat processors, traceability systems. Samples are generally taken at the time of slaughter, although they can alternatively be taken at birth and/or at breeding, and stored by Eurofins in a reference database. Control samples can also be taken at different stages of the chain, at the breeding stage, in the abattoir, or at the point-of-sale and recorded in the Eurofins database. These samples are electronically attached to documents from an existing paper-based traceability system. DNA profiles of the reference and control samples are analysed using microsatellite markers.

**PorkTrac** is a joint venture between Maple Leaf Foods Inc. of Toronto, Canada and Pyxis Genomics Inc. of Chicago, USA using DNA technology for pork traceability (www.mapleleaf.com.). A third-party, Orchid, develops assay technology using a panel of highly informative single nucleotide polymorphisms (SNPs) and a fourth party, IBM, is involved in creating and managing the database and search engine to match DNA from a piece of meat to the maternal sow and therefore the farm of origin. The programme is promoted as enabling Canadian pork marketed anywhere in the world to be traced in a matter of hours from the store shelf back to the farm where the meat originated and even back to the animal's mother. PorkTrac has received widespread support from both industry and government, including the Canadian Meat Council, and is now due for launch.

**SureTrak®** is an Australian beef traceability system marketed by Genetic Solutions that is essentially the same as easiTrace™ and also uses microsatellite markers (http://www.geneticsolutions.com.au). A 'meat smear' is taken at slaughter or grading in a tamper-evident collector. Genetic Solutions then stores the samples off-site in a secure and climate-controlled storage facility. When a trace is activated, the product is sampled and the processor's internal tracking and batching system used to identify the batch of carcasses from which the product was derived. The stored samples of DNA are tested and a match found.

**TraceBack™** is a DNA traceability system offered by Irish company, Identigen (http://www.identigen.com). The system was developed for the beef industry using microsatellite markers, although the website now contains links that signal a change to the use of SNPs (Plancon *et al.*, 2005). Biological reference samples are collected in the abattoir or on the farm, 'specially' treated, logged into Identigen's proprietary sample database and archived. Of critical importance is the association between a reference sample and the permanent identification (or as is now required in the EU, the passport) of the animal. This link can be used to associate cuts of meat with the life history of an animal at a later stage. A second (verification) sample is collected in the retail outlet and associated with a particular batch of animals through the processor's existing paper-based traceability system. A DNA analysis is conducted on the verification sample,

and its associated carcass, or reference samples and profiles matched using a computer database. TraceBack™ is marketed primarily as an auditing tool for meat works traceability. A positive match indicates that the sample comes from the batch specified; that the traceability system is working effectively and also identifies the animal within the batch the meat came from. No match is interpreted as indicating that there is an error in the processor's traceability system.

**DNA traceability as a marketing tool**

Supermarket chains have been quick to advertise DNA traceability, and several claim to have been the first. Irish supermarket chain SuperQuinn in an undated website article states that; "Two years ago, SuperQuinn became the first supermarket in the world to guarantee the absolute traceability of all its beef from pasture to plate, using TraceBack, a revolutionary new scientific system" (http://www.superquinn.ie). An article on Identigen's website suggests that SuperQuinn first began using TraceBack in 1998.

UK supermarket giant Sainsbury's state on their website (http://www.j-sainsbury.co.uk) that; "By working in partnership with the whole chain Sainsbury's was able to launch, in 2000, DNA traceability to its premium beef range. This was a first in the UK and guaranteed that our premium beef can be traced to specific animals on approved farms. This gives the customer extra confidence in the beef we sell".

In a press release dated March 12 2001 (http://www2.marksandspencer.com), Marks and Spencer claimed it was "…set to lead the way in the ultimate traceability of food products through advancements in DNA technology that means the retailer will know the precise origin of its raw meat products - all the way back to the specific animal."

**DNA solutions that enhance traceability options**

There are a number of DNA–based options marketed in conjunction with traceability products that while not being strictly traceability options, do enhance traceability of meat.

**DNA Tag** is manufactured by Allflex and marketed in conjunction with Genetic Solutions' SureTrak as a simple but effective method of collecting animal DNA (http://www.allflex.com.au). The technology uses a mixture of visual, electronic and DNA identifiers. A DNA sample taken at tagging allows a DNA profile or 'fingerprint' of the animal to be created, enabling trace forward of the animal from that point. DNA is sampled by extracting hairs from the tail switch, ensuring the follicles remain intact and the sample is dry and free from dust and dung. The follicle ends of the hairs are placed on the sticky portion of a provided sample collector that carries the same number as the ear-tag, and sent to Genetic Solutions for storage.

**FoodExpert-ID®** is a product developed by bioMérieux, and is based on a high-density DNA chip, marketed as the GeneChip, developed by Affymetrix (http://www.biomerieux.com). The test claims the capacity to detect simultaneously 33 different species of vertebrate, and to identify animal products present in food and feed samples. FoodExpert-ID can be used to test raw foods as well as products processed at high temperatures and pressures, as is the case for some animal feed. BioMérieux claim that these capabilities out perform conventional food analysis techniques, which can detect only a limited number of species, and which are less reliable when material from more than one species is combined into a single product.

**GeneStar®** is a sister product to SureTrak®, which offers DNA marker tests for production traits in cattle (http://www.geneticsolutions.com.au). Each animal is given a 'Star' rating for the trait based on the number of copies of the gene/marker being tested (1 star = a single copy, 2 stars = a double copy). Currently, tests are offered for tenderness and marbling. In traceability terms, GeneStar® is also useful for verifying trait segregation in the offspring of selected parents.

**Integri-Tag** is a combined DNA sampling, radio frequency identification (RFID) and preservation ear-tag marketed in the UK by Dalton (http://www.dalton.co.uk). The Integri-Tag combines a steel cutting tip with a unique preservative that captures a tissue sample in a pre-printed cone and seals it for transportation and analysis. The ear-tag is secure and tamper-proof; the cone cannot be switched from one tag to another and the sample is preserved without the need for refrigeration. This system is described as enabling confirmed tissue sampling in a more effective manner than hair or blood sampling. The Integri-Tag is available in standard or electronic versions where each button is encoded to a 'WYSIWYG' format – 'What you see is what you get' -: The number printed on the tag is also encoded on the transponder chip.

**ZebuCheck™,** a secondary product of TraceBack™ (http://www.identigen.com/), is based on the principle that while European cattle breeds are entirely of *Bos taurus* extraction, a large proportion of South American breeds incorporate the humped Zebu or *Bos indicus* genes. There are issues, be they real or perceived, related to meat from Zebu animals being of lower quality than meat from European breeds. Furthermore, the distinctive *Bos indicus* hump is not always passed on, and so the crossbred phenotype does not always signal the presence of *Bos indicus* genes. ZebuCheck™ is advertised as providing the ability to detect the presence of 'inferior' Zebu genes in crossbred animals. Castaldo (2003) reported a labelling scandal in the domestic Irish beef market. Ireland imports some 17,500 tonnes of beef annually. About one third of this is serviced by Brazil and Argentina where Zebu-derived cattle are used extensively. In 2003, the Irish Farmers Association purchased 53 samples of beef from a combination of supermarkets, hotels, fast food outlets/restaurants, butchers and meat wholesalers, and submitted them for Zebu diagnostic DNA testing. Of the 53 samples, 15 were positive for one or more Zebu-specific alleles, indicating non-European origin. Of these 15 samples, 12 were being sold either labelled as or placed on restaurant menus as 'Irish' beef.

**Current New Zealand research in DNA traceability**

There are currently two FRST-funded research programmes investigating DNA-based traceability of meat. Summaries of the work of each programme to date can be viewed on the FRST website (http://www.frst.govt.nz).

*AgResearch*

AgResearch is investigating the use of DNA traceability as a means of batch verification and to enable producers to offer DNA traceability in niche markets (Shackell, 2004). The programme addresses international moves towards improved traceability of foodstuffs and is aimed at providing suppliers with a solution to strategically position themselves in markets where traceability is either mandatory, or provides an advantage in niche markets where consumer pressure demands traceability for quality assurance.

In most of the marketplaces where traceability has become legislated, ground beef has been excluded or limited to COOL labelling only. AgResearch is moving DNA technology into tracing compound products. Currently, it has been shown that it is possible to assign a single meat patty sample to its correct batch of origin on the day of production in a situation where there are 10 possible batches each containing around 7000 patties (Shackell *et al.*, 2005). The next step is to identify the individual animals that contributed to that batch and trace them back to the property of origin.

This project is also developing methods to identify unique genotypes within a mixture at very low concentrations. By achieving this, DNA traceability of milk products would become feasible.

*Global Technologies*

Global Technologies are developing a DNA traceability system designed to rapidly track meat and other food products from the consumer and retailer to the country and farm of origin (Hill, 2004). The objective is to design instrumentation and reagents for use in global food retailing and processing industries. The provision of real-time information delivered through global telecommunication networks will allow validation of product source and safety, efficient product recall, timely treatment of food poisoning and rapid surveillance of animal-related diseases.

The expected technologies will integrate biotechnical methods into the food processing industry to provide guarantees of quality, safety and farm-of-origin for meat-based products. The DNA-based traceability system will allow tracking of meat from plate to gate and will also provide the scope to integrate with information on production characteristics, bacterial contamination, residue levels, and genetic modification status.

Perceived advantages for the grower will be an ability to tailor production to end-user needs by providing early feedback on market requirements. For the consumer, the technology will help provide origin, content and credence guarantees.

## SUMMARY

NZ depends on meat exports for about 30% of its GDP. Internationally, traceability of meat and meat products is a major issue. While there are many traceability products marketed around the world, it is impossible to list and/or review all of them in this forum. Therefore, I have attempted to list, without prejudice, some examples of systems that are currently in use, or being developed, for application in the meat industry. Paper-based traceability is well established, but may have issues with transparency and credence. DNA-based traceability is still relatively new, and expensive, but it exploits the unique 'biological barcode' that every piece of meat carries.

## REFERENCES

Annual Review of the New Zealand Sheep and Beef Industry, 2002-2003

Castaldo, D. 2003: Brazilian beef labelled Irish. *MeatNews.com Online*, 26 September 2003

Clemens, R.; Babcock, B.A. 2004: Country of Origin as a Brand: The case of New Zealand lamb. *MATRIC Briefing Paper 04-MBP 9 Retrieved March 14 2005 from* http://www.matric.iastate.edu

Hill, D. 2004: Real-time Detection of Biomarkers. *Research Abstract and Report Databases, Foundation for Research Science and Technology* (http://www.frst.govt.nz)

Hird, V.; Emerson, C.; Noble, E.; Longfield, J.; Williams, V.; Goetz, D.; Hoskins, R.; Paxton, A.; Dupee, G. 1999: Food miles – Still on the road to ruin? *Retrieved March 14, 2005, from* http://www.sustainweb.org

Ozawa, T.; Lopez-Villalobos, N.; Blair, H.T. 2005: An update on beef traceability regulations in Japan. *Proceedings of the New Zealand Society of Animal Production 65:* 80-84

Plancon, C.; Duva, D.; Henry, E.; Kuckarzak, R.; Lechner, D.; Meghen; C., Angiolillo, A.; Sanchez, A.; Gut, I.G. 2005: Evaluation of a panel of SNP markers for traceability of cattle. R*etrieved March 14, 2005, from* http://www.identigen.com/

Shackell, G. 2004: DNA analysis of ground beef. *Research Abstract and Report Databases, Foundation for Research Science and Technology* (http://www.frst.govt.nz)

Shackell G. H.; Tate M. L.; Anderson, R. M. 2001: Installing a DNA-based traceability system in the meat industry. *Proceedings of the Australasian Association for the Advancement of Breeding and Genetics 14:* 533-536

Shackell G.H.; Mathias, H.C.; Cave, V.M.; Dodds, K.G. 2005: Evaluation of microsatellites as a potential tool for product tracing of ground beef mixtures. *Meat science 70:* 337-345

Smith, P.G., Cousens, S.N.; Huillard d'Aignaux, J.N.; Ward, H.J.T.; Will, R.G. 2004: The epidemiology of Variant Creutzfeldt-Jacob Disease. *Current topics in microbiology and immunology 284:* 161-191

Sutton, The Hon J. 2005: Address to the Retail Meat conference, Wellington, NZ. *Retrieved March 154, 2005, from* http://www.beehive.govt.nz