# Framework for a voluntary traceability system for beef

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# Declaration

I, Petronella Anne Calitz, hereby declare that this dissertation submitted for the degree of *Magister Agriculturae* in the Faculty of Natural and Agricultural Science, Department of Agricultural Economics at the University of the Free State, is my own independent work, and has not previously been submitted by me to any other university. I furthermore cede copyright of the thesis in favour of the University of the Free State.

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## Abstract

In recent years, food safety and food quality have become important issues in the global beef industry. Traceability can be seen as an important tool for ensuring safety and quality of beef products. Consumers have also become more aware of what they buy and they require more information on the origin of foods. These are the main reasons why traceability is a requirement for all beef imported into countries and regions such as Australia, Japan, South Korea and the European Union states.

Although there are African countries with mandatory traceability systems (Namibia and Botswana), South Africa does not have such a system in place and is therefore excluded from exporting beef products to certain markets. The main aim of this study was to establish a framework for a voluntary beef traceability system for South Africa that complies with all international standards and the requirements of countries which require traceability of beef imports.

The objectives of this study were to a) get clarification of an ideal traceability system that meets international standards, b) assess of the current South African laws and the classification system and ascertain how it can assist in traceability implementation, and lastly c) propose a framework for a farm to fork beef traceability system for South Africa.

An in-depth review was done on the current status of beef traceability in the world, as seen in Article 1. This study included the current systems implemented by some of the biggest importing and exporting countries and economic unions in the world, which included Brazil, Australia, EU states and Japan, to only name a few. Traceability

standards were also studied to gain a good understanding of what the requirements are for a globally acceptable traceability system. The three well-known conceptual frameworks were also included in this part of the study and included the CTE and KDE framework, Food Track and Trace Ontology, and lastly the TraceFood Framework. Thereafter, the existing traceability systems were divided into three levels according to depth, breadth and precision. In this part of the study, the current status of traceability in the South African beef industry in relation to other beef producing countries and economic union is also briefly discussed.

The next step in this study was to establish a traceability system using the CTE and KDE framework. It was important to establish the CTEs and KDEs for each of the role-players in the value chain to ensure the link from live to final product is not broken. After the framework for each role-player was established, a few benefits were also identified for the adoption of this framework. It was important to ensure that this framework would take all global, as well as South African, laws and regulations into account.

The results of this study are that a framework for a voluntary beef traceability system can be established. By adopting this framework, all participants will have access to the same benefits as those in countries with mandatory traceability systems. This voluntary traceability system can also form part of a pilot study for a mandatory traceability system for the South African beef industry.

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# Chapter 1 Introduction

## 1.1 Motivation and Background

World food safety has become a very important factor over recent years. According to Sarig (2003), approximately seven million people are affected each year by food-borne illnesses. Statistics like these have forced countries to put certain measures in place to prevent these events from occurring.

During 1984 to 1987, an outbreak of Bovine Spongiform Encephalopathy (BSE) caused consumers to lose confidence in beef products in the United Kingdom. Countries suspect that there is a relationship between BSE and variant Creutzfeldt-Jakob disease in humans (Souza-Monteiro and Caswell, 2004). This motivated countries and economic union to introduce traceability of beef products to protect human health. In 1986, the European Union introduced the Single European Act. By doing this, they allowed the European Commission to propose measures that will give consumers a high level of protection. In January 2000, the European Union introduced the White Paper on Food Safety. This Paper contained the new European legislation as well as specific deadlines for the most important parts of the legislation. The European Union wanted to use this policy to regain consumers' confidence through the sharing of information along the food chain.

Even before the European Union decided to introduce food traceability, Australia implemented a very basic traceability system. This system was implemented in the early 1960s as part of a plan to eliminate tuberculosis as well as brucellosis in livestock. Over the years, Australia's traceability system developed into the National Livestock Identification System (NLIS) that is in use today. A new animal identification system was introduced by Brazil in January 2002 in an effort to better their traceability system (Souza-Monteiro and Caswell, 2004, Schroeder and Tonsor, 2012, Smith *et al*.2008).

One of our neighbouring countries in Africa, Namibia, has a traceability system that complies with global standards. Traceability systems, like these being discussed, help countries to gain access to global markets. For some of these countries like Australia, their traceability system is of utmost importance as they need it for their agricultural industry which focuses mostly on livestock production, and their focus markets are mostly the prestige expensive markets where traceability is a very important requirement (Australian White Paper, 2016). The United States of America is the only big exporting country which has only a voluntary system, where companies and primary producers have a choice whether they wish to adopt a traceability system or not. Even without formal governmental legislation, these companies are able to export to countries and regions where traceability is required.

In research done by Zhang and Bhatt (2014), they recognised that while there is no uniform global system which is used by all countries, there are certain data elements which need to be recorded in a basic system. A code of Best Practices has been drafted for six different industries, with the beef industry being one. This code of Best Practices determine which Critical Tracking Events (CTEs) and which Key Data Elements (KDEs) need to be recorded in a basic traceability system. The choice is with the companies to decide whether they want to commit to the basic system, or if a more advanced system based on more advanced technology is the preferred choice.

In the past, the biggest trade barriers that prevented market access comprised tariffs. Over recent years, non-tariff barriers have emerged and now comprise a major tool in international trade. These can help countries to gain access to global markets, but at the same time, they can prevent others from having access. The new non-tariff barriers that have the biggest influences on international trade barriers are Sanitary and Phytosanitary Standards (SPS), as well as related animal identification and traceability protocols. The European Union (EU) uses animal identification and traceability as tools to manage public and animal health, and to provide consumers with the information they demand and are willing to pay for. These systems are also used as tools for the functioning of the market and fraud prevention, and are also important for crisis management.

The most important information that is provided by animal identification and traceability is information about animal origin and age verification. According to Pavon (2014), animal identification and traceability requirements should be seen as providing an opportunity to gain a competitive advantage, rather than as being an obstacle. The future of bilateral trade is moving towards traceability and those countries who do not adapt will be left out of trade negotiations. Even though the standards and systems differ between countries, all these counties have the same underlying theme, which is farm-to-slaughter or farm-to-retail traceability. The motivation for the implementation of traceability is the same or very similar for each of these countries, and that is to protect human and animal health, and to safeguard consumers' confidence.

Golan, Krissoff, Kuchler, Calvin, Nelson and Price (2004) divided a traceability system into three main characteristics namely, breadth, depth and precision. The amount of information the system records is called the breadth, whereas the ability to pinpoint the original source of the problem will reflect the precision of the system. The depth is about how far forward and how far backward the traceability system is maintained. There also exist two different traceability systems, namely internal traceability and external traceability. Internal traceability is the traceability within one company, and external traceability is traceability along the entire food chain.

A traceability system's full economic impact is very extensive and consumers' willingness to pay for a traceability system differs from country to country. French consumers are consumers who are willing to pay for increasing levels of transparency and traceability (Latouche *et al*., 1998). On the other hand, Canadian consumers are not that willing to pay for traceability on a beef sandwich worth C$2.50. According to experiments conducted by Dickinson and Bailey (2005), they are willing to pay a premium of less than 10 per cent. Other countries and companies have not introduced traceability for direct gains like a price premium, but rather for economic benefits such as its impacts on food safety and animal health, and the influence it has on production management decisions. According to Souza-Monteiro and Caswell (2004), the four main areas of economic impact which arise from a traceability system are on human and animal health, liability, trade, and effects on the supply chain.

In South Africa, we do not have national regulations which compel farmers to introduce a traceability system. Even without formal regulations, the fruit industry was very successful in introducing a system and exporting to the EU where such a system is required. However, given the international brand and also the possibility of beef exports from South Africa to other markets, i.e. African markets, the implementation of a voluntary traceability system for the processors/exporters could give better market access.

## 1.2 Problem statement and objectives

### 1.2.1 Problem statement

Research has been done on the traceability systems of various countries and economic union, such as the United States of America, Australia, New Zealand and the European Union states (Souza-Monteiro *et al*., 2004; Schroeder and Tonsor, 2012; Verbeke and Ward, 2006; Charlebois *et al*., 2014). There are also various global standards, best practices and regulations for traceability that can be found in the literature (Zhang and Bhatt, 2014; EC No 1792/2006, ISO 2000, GS1, 2012). A limited amount of research has been done on traceability in South Africa. Some research has been done on the fruit sector (Olivier, Fourie and Evans, 2006) while more extensive research has been done on Karoo lamb and the influence of traceability on the brand (Du Plessis and Du Rand, 2012; Van der Merwe, 2012). No research has been done of a voluntary beef traceability system for South Africa. The lack of traceability is one of the reasons why South Africa is excluded from certain beef export markets. Traceability has become an important non-tariff barrier in recent years (Frohberg *et al*., 2006). Traceability can also assist in brand building, which will become more important in the future (Buhr, 2003).

### 1.2.2 Objectives

#### *1.2.2.1 Main objective*

The main objective of this study is to establish a globally recognised framework for a voluntary beef traceability system in South Africa.

#### *1.2.2.2 Sub-objectives*

The sub-objectives of this study are to provide:

- A clarification of an ideal traceability system that meets international standards for the beef industry.

- An assessment of the current South African laws and classification system and whether these can assist in traceability implementation.
- A proposal of a voluntary beef traceability system for South Africa.

# Chapter 2 Literature Review

## 2.1 Food safety

The United States, according to estimations, encounters a huge number of foodborne illnesses each year. According to a study done by Mead *et al*. (1999), the number of hospitalisations during the reporting period was approximately 325 000, with 76 million illnesses suffered a year, from which about 5000 deaths ensued. According to the same study, it seems there were fewer deaths, despite foodborne diseases and more numerous outbreaks.

Recall summaries of food products published by the United States Department of Agriculture (USDA) show there was a total of 94 recalls in 2014 which recalled a total of 18 675 102 pounds of meat. Twenty-two of these recalls were for beef products totalling 13 232 176 pounds. Some of the reasons for the recalls as stated in the report are salmonella, Listeria monocytogenes, undeclared substances, and processing defects (USDA, 2014). The total of number of cases with salmonella comprised 372 424 pounds, which were covered in four recalls (USDA, 2014).

ENCA (a 24-Hour television news broadcaster focusing on South African and African stories) reported in October 2014 that Tiger Brands (a South African food company) recalled 17 000 units of food which contained traces of unsafe colourants. The products recalled were Tastic rice products.

In 2007, a Chinese company called Menu Foods had a recall of 60 million units of pet foods. According to an event study done by Allen *et al*. (2008), Menu Foods had experienced an 82 % market adjusted price decline, which explains the company's $178 million decline in market capitalisation. Allen *et al*. (2008) also included news excerpts regarding all the recalls in Chinese products in 2007. Various pet food companies, such as Hills pet nutrition, had recalls. Menu Foods, P&G, Royal Canon as well as Nestle Purina. The FDA also issued an advisory, mentioning approximately 10 brands, for customers to avoid all toothpaste produced in China.

## 1.1 2.2 Overview on the Global Beef industry

Total meat consumption in the world is estimated to increase from 41.3 kg to 45.3 kg per capita from 2015 to 2030. The livestock sector accounts for 40 % of the global gross value of agricultural production (FAO, 2003). Beef prices have been increasing in China since 2000, and Rabobank believes that China will demand 2.2 million tonnes more beef by 2025. There are also niche markets developing in China for beef and a small group of consumers are willing to pay a premium price for value-added products. There is currently a short supply of beef in China, which is the reason for the high and still increasing prices.

The Food Outlook of the Food and Agricultural Organisation of the United Nations (FAO) for 2015 indicated that there was only a slight increase of 0.2 % in beef production for 2015. There was a trade increase of 1.7 % in beef, while the global per capita consumption of beef only increased by 0.1 %. Considering these statistics, it makes sense that the price change for January to April 2014 showed a 3.6 % decrease. According to FAO projections, Brazil is the second largest producer of beef, with the United States being the largest. Beef production is expected to increase by 1.6 % to 10 million tonnes. Given the good rainfall in certain parts of Africa, bovine production is an important industry and plays an important part in food supplies. Diseases in African beef production are common and vary, for example there were outbreaks of foot-and-mouth disease (FMD) in countries such as Kenya, Uganda and Rwanda, which place extra constraints on the industry and relate to food safety.

According to the South African Department of Agriculture, Forestry and Fisheries (DAFF, 2012) the global livestock industry contributed 15 % of total food energy and 25 % of dietary protein.

## 2.3 Overview on South Africa's Beef industry

South Africa has 80 % of its land surface being utilised for agriculture. Livestock production uses 70 % of this surface. Animal production is the largest industry in the South African agricultural sector and contributes 47.2 % to total production. Thus, livestock production is very important in the agricultural sector of South Africa (Spies, 2011). Spies (2011) also believes that South Africa does have the potential to become a market leader in livestock production in Sub-Saharan Africa. As part of his study, he interviewed 143 commercial producers who stated that 60 % of their income was generated from livestock farming. The average calving percentage in the surveyed commercial beef herds was 80 %. The smallholder farmers had a calving percentage of only 30 %. Most of the weaners were marketed to the feedlot sector, while most of the older animals were marketed to the primary sector. In this study, it was seen that smallholder farmers still have very limited market access and are limited to their local auctions.

Part of the marketing constraints of smallholder farmers which were identified by Coetzee *et al.* (2005) was the unwillingness of smallholder farmers to adopt an animal identification system.

Most land in South Africa is only suitable for extensive grazing. The South African beef industry grew with 2 %, or by 238 000 head of cattle, from 2002/3 to 2012. The South African beef farmers vary from sophisticated, commercial farmers who use much technology, to subsistence farmers. Commercial farmers own 60 % of the South African cattle population, while the other 40 % are owned by emerging and subsistence farmers. In 2012, South Africa was home to approximately 11 million beef cattle. Mpumalanga is the province which produces the most beef, with 22 % of total production, followed by the Free State with 20 %. It is estimated that South Africa has 500 abattoirs where approximately 2.3 million cattle are slaughtered annually. The dominant feedlots are mostly integrated producers and processors, and they have also started to integrate into their own retail outlets. An estimated 7.5 billion kilograms of beef were produced in the past ten years (DAFF, 2012).

The South African cow herd has decreased by as much as 15 % since 2013 due to drought. In the Free State and North West, the cow herd decreased by up to 17 % in 2016, in comparison with 2015. The expectation is that the supply of beef will decrease and that beef will become more expensive, and that consumers will require a quality product for their money.

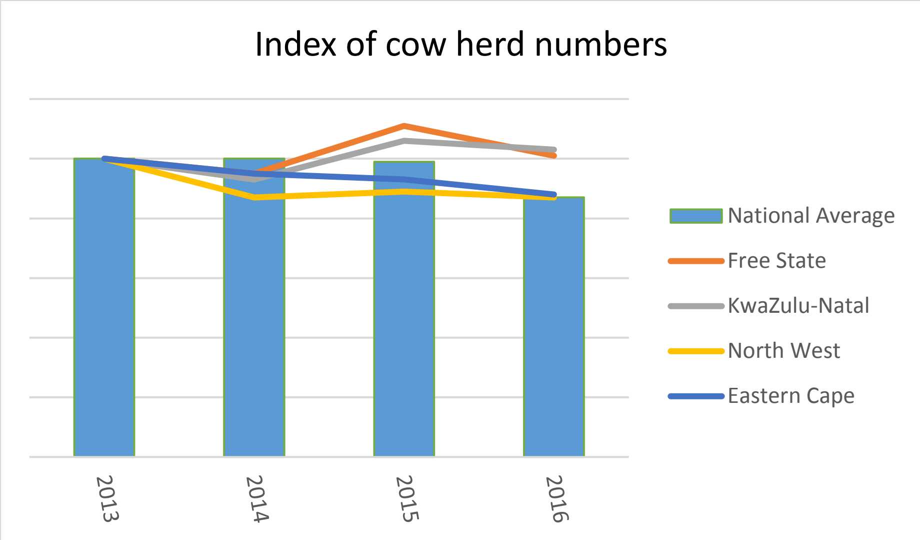



*Figure 2.1: Index of Cow Herd Numbers*

Source: BFAP (2016)

### 2.3.1 Contribution of the beef industry to South Africa's economy

Meat consumption increased in South Africa in the past decade due to an increase in income levels and urbanisation. The increase in beef consumption amounted to 19 % over the past decade. South Africa's economic growth rate is slowing down and therefore the growth in meat consumption is expected to slow down in the next decade. Integrated feedlots have optimised carcass value by exporting high-value cuts, mostly to Middle Eastern countries, during the past three years, which has supported earnings and thus has helped to stabilise producers' prices. Prices for A2/A3 carcasses increased by 4 %, while the commercial slaughter volumes increased by 9 % during the same period. While South African domestic beef prices remained constant at R34/kg, the average export price increased to R46.16/kg in the fourth quarter of 2015 (BFAP, 2016).

### 2.3.2 South African beef exports

Income received from beef exports is important for the South African integrated feedlots and primary producers. According to statistics received from SARS (2015), most of the beef products are exported to African and Arabian Countries while there are also exports to Asian and European countries, with only a small amount going to the Americas. The export volumes continue to grow and are becoming an important source of income for the industry. However, given the fact that South Africa does not have a beef traceability system, the risk remains that these export markets will increase their requirements for an acceptable beef traceability system. These requirements enable export markets to verify the movement of the product and also to trace the origins back, in cases where potential risks may be identified.

#### *2.3.2.1 South African Beef Exports to African countries*

In Table 2.1, the exports to African countries are summarised and it clear that the income received from these exports are important to South Africa's cattle industry as it is an important source of foreign revenue. The total income received from exports to Angola was R170 million, with an average price of R61.90 per kg. It is important to remember that these are only certain cuts being exported, and not carcasses. Lower price cuts were exported to Lesotho at a price of R20.52/kg, but nevertheless contributed R194 million to the South African cattle industry. Exports to Mozambique totalled R435 million, at an average price of R36.41/kg, while the price per kilogram for exports to Swaziland was R29.80, totalling just less than R300 million. The highest average price per kilogram received for exports to an African country was R153 to Benin, and therefore one can conclude that it was high quality cuts that were exported.

*Table 2.1: South African Beef Exports to African Countries*

| **Country** | **Month** | **Price Per KG** | **Quantity (KG)** | **Total Income** |
|---|---|---|---|---|
| Angola | January 2013-October 2015 | R 61.91 | 2 758 312 | R 170 777 274 |
| Burundi | February-May 2013 and June and October 2015 | R 65.35 | 256 | R 16 730 |
| Benin | February and April 2014 | R 120.05 | 66 | R 7 923 |
| Botswana | January 2013 to October 2015 | R 25.80 | 1 700 218 | R 43 859 184 |
| Democratic Republic of the Congo | January 2013 to October 2015 | R 37.16 | 1 339 234 | R 49 765 431 |
| Congo | January 2013 to October 2015 | R 75.08 | 276 776 | R 20 780 594 |

| | | | | |
|---|---|---|---|---|
| Ivory Coast | April 2013 to October 2015 | R 52.79 | 294 725 | R 15 558 894 |
| Cameroon | February 2015 | R 92.08 | 100 | R 9 208 |
| Cape Verde | March 2013 | R 153.80 | 102 | R 15 688 |
| Eritrea | April 2013 and March 2014 | R 117.27 | 62 | R 7 271 |
| Ethiopia | April 2013 to October 2015 | R 103.62 | 12 911 | R 1 337 868 |
| Gabon | January 2013-October 2015 | R 86.28 | 243 710 | R 21 027 835 |
| Ghana | January 2013-October 2015 | R 83.04 | 165 876 | R 13 774 667 |
| Equatorial Guinea | June 2014, June 2015 and October 2015 | R 95.45 | 113 | R 10 805 |
| Kenya | March 2013-October 2015 | R 50.63 | 138 989 | R 7 037 583 |
| Lesotho | January 2013-October 2015 | R 20.52 | 9 477 155 | R 194 517717 |
| Liberia | October 2013-October 2015 | R 49.65 | 329 087 | R 16 339 189 |
| Libyan Arab Jamahiriya | March and September 2013, April 2014 | R 79.26 | 85 | R 6 737 |
| Mauritius | January 2013-October 2015 | R 66.13 | 1 345 868 | R 89 008 954 |
| Malawi | February 2013- October 2015 | R 42.55 | 65 638 | R 2 792 602 |
| Mali | August and September 2013, January 2014 | R 54.33 | 181 640 | R 9 869 097 |
| Mauritania | January 2013-September 2013, February, March and November 2014, October 2015 | R 65.53 | 1 756 | R 115 067 |
| Mozambique | January 2013-October 2015 | R 36.41 | 11 967 618 | R 435 712 825 |
| Namibia | January 2013-October 2015 | R 41.31 | 1 809 356 | R74 747 438.99 |
| Nigeria | January 2013-October 2015 | R 86.08 | 534 728 | R 46 028 581 |

| | | | | |
|---|---|---|---|---|
| Reunion | January 2013- October 2015 | R 38.40 | 759 243 | R 29 156 943 |
| Rwanda | January 2013- July 2013, October 2014, July 2015 | R 53.72 | 673 | R 36 154 |
| Saint Helena | January 2013- October 2015 | R 51.64 | 35 084 | R 1 811 614 |
| Sudan | November 2013, March 2014, February 2015- October 2015 | R 52.18 | 332 767 | R 17 562 380 |
| Sierra Leone | August 2013, January 2014, June 2014 | R 49.39 | 32 537 | R 1 607 000 |
| Senegal | November 2013, December 2013, January – April 2014 | R 49.35 | 164 402 | R 8 113 246 |
| Seychelles | January 2013- October 2015 | R 58.25 | 480 680 | R 28 001 771 |
| Swaziland | January 2013- October 2015 | R 29.80 | 10 007 021 | R298 186 081 |
| United Republic of Tanzania | January 2013- October 2015 | R 76.17 | 94 290 | R 7 181 620 |
| Uganda | January 2013- September 2015 | R 52.89 | 9 038 | R 478 037 |
| Togo | January, July and August 2015 | R 72.46 | 18 862 | R 1 366 745 |
| Zambia | January 2013 –October 2015 | R 41.47 | 349 062 | R 14 474 082 |
| Zimbabwe | January 2013- October 2015 | R 35.01 | 593 377 | R 20 774 987 |

Source: SARS (2015)

#### *2.3.2.2 South African beef exports to Middle Eastern countries*

South Africa has exported beef mostly to African countries, although in recent years exports to Middle Eastern countries have increased. Countries to which exports have increased include the United Arab Emirates, Kuwait and Jordan, and the income from their exports exceeded R100 million from January 2014 to October 2015. All these countries can be seen in Table 2.2, which contains data received from SARS regarding these countries.

*Table 2.2: South African Beef Exports to Middle Eastern Countries*

| Middle Eastern Countries | | | | |
|---|---|---|---|---|
| Country | Month | Price Per KG | Quantity (KG) | Total Income |
| United Arab Emirates | January 2013, August 2014-October 2015 | R 62.44 | 1 970 750 | R 123 109 899 |
| Egypt | May 2013-October 2015 | R 57.85 | 1 546 516 | R 89 469 506 |
| Islamic Republic of Iran | October 2015 | R 118.13 | 32 | R 3 780 |
| Jordan | April 2013-October 2015 | R 55.83 | 4 841 325 | R 270 306 315 |
| Qatar | January 2013-October 2015 | R 73.74 | 761 417 | R 56 148 254 |
| Saudi Arabia | April, August and September 2014 | R 26.67 | 304 | R 7 500 |
| Bahrain | January 2013-October 2015 | R 21.19 | 917 444 | R 19 441 436 |
| Kuwait | January 2013-October 2015 | R 65.12 | 6 437 651 | R 419 243 872 |
| Oman | April 2013-September 2015 | R 73.41 | 60 426 | R 4 435 891 |

Source: SARS (2015)

The total income received from exports to Kuwait was just below R420 million, at an average of R65.12/kg, with up to 406 000 kg of beef a month being exported. From January 2013 to October 2015, 4.8 million kg of beef was exported to Jordan at an average price or R55.83/kg. It is not clear exactly which cuts was exported, but one can accept that these would be the more expensive cuts. The highest average price for beef exported to a Middle Eastern country was R118/kg, for a very small amount of beef exported to the Islamic Republic of Iran (SARS, 2015).

### *2.3.2.3 South African beef exports to European Countries*

Table 2.3 summarises the beef exports to European countries where traceability plays a very important role. Of the 15 European countries to which South African beef was exported, the biggest income was received from Italy, the Netherlands, Norway and the British Crown Dependency of the Isle of Man, with more than R100 million earned from each of these countries over the period from January 2013 to October 2015.

*Table 2.3: South African beef exports to European countries*

| Europe | | | | |
|---|---|---|---|---|
| Country | Month | Price Per KG | Quantity (KG) | Total Income |
| Antarctica | November 2013 and December 2014 | R18.74 | 26 007 | R487 470 |
| Belgium | August 2013 and April 2015 | R30.63 | 21 932 | R671 693 |
| Bulgaria | August 2013 | R72.46 | 138 | R10 000 |
| Spain | October 2013 | R148.50 | 10 | R1 485 |
| France | January 2013-December 2014 | R201.74 | 4 125 | R832 162 |
| Greece | June 2013-October 2015 | R33.11 | 2 455 249 | R81 300 113 |
| Ireland | May 2014, April 2015 and June 2015 | R31.05 | 114 925 | R3 568 422 |
| Italy | January 2013-October 2015 | R36.25 | 2 765 601 | R100 246 071 |
| Malta | June-August 2013, January 2014- October 2015 | R44.52 | 584 259 | R26 015 920 |
| The Netherlands | January 2013-October 2015 | R39.57 | 7 938 881 | R314 150 250 |
| Norway | January 2013-October 2015 | R46.14 | 2 753 431 | R132 541 423 |
| Sweden | December 2014 – October 2015 | R54.88 | 480 121 | R26 347 142 |
| Turkey | February 2015 | R99.66 | 80 | R7 973 |
| Norwegian Sector | November 2013 | R68.05 | 281 | R19 121 |
| Isle of man | January 2013-October 2015 | R42.36 | 20 916 659 | R885 961 659 |

Source: SARS (2015)

The highest average price received from a European country was R201.74/kg, for meat exported to France, while the most beef exported to a European territory was to the British Crown Dependency of the Isle of Man, which totalled R885 million.

#### *2.3.2.4 South African beef exports to Asian countries*

Table 2.4 summarises all beef exports to Asian markets, which comprise some of the growing markets with much growth potential. The only exporting destination in Asia that exceeded more that R200 million was Hong Kong, which received close to 5 million kilograms of beef between 2013 and 2015. The highest average price was received from exports to the Russian Federation, although only 52 kg was exported there.

*Table 2.4: South African beef exports to Asian countries*

| Asian Countries | | | | |
|---|---|---|---|---|
| Country | Month | Price Per KG | Quantity (KG) | Total Income |
| China | February and September 2013, February 2014 | R 30.69 | 52 680 | R 1 616 698 |
| Hong Kong | January 2013-October 2015 | R 43.97 | 4 982 588 | R 219 083 627 |
| Cambodia | October 2014 and August 2015 | R 77.79 | 8 552 | R 665 295 |
| Comoros | June-August 2013, June 2014 and October 2015 | R 53.90 | 35 002 | R 1 886 534 |
| Maldives | March 2013-October 2015 | R 182.53 | 48 589 | R 8 868 762 |
| Russian Federation | July 2013 | R 240.38 | 52 | R 12 500 |
| Singapore | November 2014- October 2015 | R 43.26 | 593 567 | R 25 676 160 |
| Thailand | June 2013-June 2015 | R 39.33 | 1 138 326 | R 44 767 256 |
| Vietnam | October 2013-October 2015 | R 41.60 | 5 739 066 | R 238 721 717 |

Source: SARS (2015)

*2.3.2.5 South African Beef exports to North and South America*

South and North America are the two continents where the least amounts of South African beef products have been exported to. Therefore, the income received from these exports has not contributed to the South African cattle industry to the same extent as the exports to other continents have.

*Table 2.5: South African Beef Exports to the Americas*

| Americas | | | | |
|---|---|---|---|---|
| Country | Month | Price Per KG | Quantity(KG) | Total Income |
| Canada | June 2013 | R 2 275.56 | 254 | R 577 991 |
| Colombia | March and November 2013 and February 2014 | R 41.76 | 1 791 | R 74 785 |
| Falkland Islands (Malvinas) | October 2013 | R 4.32 | 180 | R 778 |
| Panama | January 2013-February 2015 | R 21.43 | 46 233 | R 990 697 |
| United States of America | November 2013 | R 70.19 | 27 | R 1  895 |

Source: SARS (2015)

Given the volumes of beef exports already taking place and the income earned, it is clear that the beef export market is becoming an important contributor of income to the cattle industry. Implementing a standardised and an internationally acceptable traceability system for South African beef exports is becoming an urgent requirement to safeguard market access to these markets and to grow the volumes. The risks of food safety issues without such a system are relatively high.

## 2.4 South Africa's current beef classification system

Polkinghorne *et al*. (2008) reviewed the major grading and classification systems in the world and focused on their origin and history, as well as their evolution over the years. They discussed the system of a group of seven countries which comprise Japan, Australia, the Republic of South Africa, Canada, Europe, South Korea and the United States of America. Out of all these countries and economic union, the only countries and economic union with a meat system that are regarded as a classification system are Europe, Australia and South Africa.

Strydom (2011) discussed the history and evolution of the South African beef system, up to the system that we are currently using. The South African classification system comprises an age classification, fat classification, conformation classification, and damage classification.

### 2.4.1 South African laws and regulations on the beef industry

There are various national and international Acts and regulations that need to be in place at various points in the meat value chain. These laws and regulations are indicated and enforced internationally by the International Meat Quality Assurance Service (IMQAS), while the local enforcers of these laws and regulations are the Red Meat Abattoir Association (RMAA) and the South African Meat Industry Company (SAMIC). The South African Acts and regulations, which are of concern to the above-mentioned organisations, are the Meat Safety Act (40 of 2000), the Red Meat Regulations (R1072) issued under that Act, the Agricultural Product Standards Act (119 of 1990), certain regulations under the Foodstuffs, Cosmetics and Disinfectants Act (54 of 1972), and the Consumer Protection Act (68 of 2008). The Stock Theft Act (57 of 1956) and the Animal Identification Act (6 of 2002) are also important Acts, especially for farmers, auctions, feedlots and abattoirs. The ISO 9000:2000 standards are also highly implemented and regulated in the South African meat industry and will be discussed in more depth in the following paragraphs.

#### *2.4.1.1 The Animal Identification Act, 2002 (6 of 2002)*

The old Brands Act (87 of 1962) was replaced by the new Animal Identification Act of 2002. According to this Act, it is compulsory to mark all large and small stock, which includes pigs, goats, cattle and sheep throughout South Africa. This Act contains information on the ages at which the animals should be marked, as well as further information on the registration of identification marks and the parts and methods used to apply these identification marks (Identification of Animals InfoPAK, 2008).

#### *2.4.1.2 Stock Theft Act, 57 of 1956*

This Act ensures that certain measures are put in place to prevent stock theft from occurring, and provides measures to be taken when stock theft occurs. Various amendments have been made to the Act over the years. This Act also contains information on the movement and transportation of animals. It is also mandatory to be in possession of a removal certificate containing information from where and whom the animal was loaded, and to where and whom it will be transported. Other information that should also be included in the removal certificate covers the vehicle authorised to do the transportation (Juta Law, 2011).

#### *2.4.1.3 The Meat Safety Act, 40 of 2000*

The main aim of the Meat Safety Act is to establish national standards for abattoirs and to implement these standards to ensure and promote the safe production of animal products and meat. As part of the implementation of this Act, abattoirs should be inspected regularly and records of abattoir activities are collected as part of the Hygiene Management System (HMS). These records include various records, flow diagrams, and schematic plans and instructions which would ensure the safe production of meat.

#### *2.4.1.4 Agricultural Product Standards Act, 119 of 1990*

This Act addresses the voluntary classification system that is currently being used in South Africa. It also addresses all marking and classification of meat that will be sold in South Africa, as well as meat intended for exports. It also manages the marking and classification of imported meat products, and is monitored by SAMIC (Van der Merwe, 2012).

#### *2.4.1.5 Red Meat Regulations (R1072)*

The Red Meat Regulations (R1072) are issued under the Meat Safety Act, 40 of 2000, and therefore these includes various regulations relating to:

- The registration of red meat abattoirs.
- Hygiene management and evaluation systems
- Humane treatment of animals during the slaughter process
- Meat inspections

- Classification and marking
- Treatment of condemned material
- Export regulations
- Import regulations
- Slaughter of animals for own consumption and for religious and cultural purposes (Van der Merwe, 2012).

*2.4.1.6 Foodstuffs, Cosmetics and Disinfectants Act, 54 of 1972, and in particular Regulation R908.*

The two main focus points of this Act pertaining to the meat industry are the Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Points (HACCP). With HACCP, a hazard analysis is developed which comprises a list of possible hazardous points which could cause harm, with the correct controlling measures then being put in place. When a hazard analysis is conducted, it is important to take into consideration the raw materials and each step in the production process, as well as all distribution, storage, final preparation and uses by the consumer, for the development of the list of Critical Control Points (CCPs) to prevent contamination and reduce food safety hazards. As part of the development of CCPs, critical limits should be determined which will then be used to distinguish between safe and unsafe practices. As part of HACCP, it is important that a verification system is also put in place to oversee and monitor the control over these CCPs, and if not, to document it (Van der Merwe, 2012).

*2.4.1.7 Consumer Protection Act, 68 of 2008.*

The promotion of a marketplace for consumer products and services that is fair, accessible and workable is the main aim of the Consumer Protection Act of 2008, which is one of the main reasons why some companies have implemented traceability systems in their supply chains. This is done by the regulation of labelling, marketing and advertising of foodstuffs in relation to the disclosure of information and provision of warnings and instructions, and generally the forbidding of any sort of misleading or dishonest conduct (Van der Merwe, 2012).

A consistent legislative framework, with enforcement mechanisms, is promoted by this Act which relates to consumer transactions and agreements. This Act also promotes reasonable consumer behaviour and improves the standards of information received by consumers (Van der Merwe, 2012).

## 2.5 Value chain analysis and beef value chains

There is a difference between a supply chain and a value chain, and it is very important to distinguish between the two (Meyer-Stamer and Waltring, 2007). Supply chain literature is aimed at using a more efficient supply chain to gain a competitive advantage. On the other hand, one can define the value chain as the full range of activities required in bringing a product or service from conception through the different production stages to the end consumer and the disposal thereafter (Kaplinsky and Morris, 2001).

One can find literature from the early 1960s which includes Sub-Sector Analysis, which is a tool that is similar to the tool used in value chain analysis (Boomgard *et al*., 1986).

Another method used to analyse the vertical integration in French agriculture was the French 'filiere' approach, also known as the Commodity Chain Analysis. The concept describes the flow of physical inputs and services in the production of a final product (Roduner, 2005). According to Kaplinsky (2000), the use of the Filiere approach stops at the national boundaries most of the time, and this approach is mostly used in domestic value chains, as it is very static.
Because of this shortcoming, Gereffi and Korzeniewicz (1994) introduced the Global Commodity Chain (GCC) in the mid-1990s and this new approach focuses mainly on international trading systems. Part of this approach focuses on increasing economic integration of production and marketing chains (Roduner, 2004). He also stated that one of the main characteristics of the value chain is that it is managed by a dominant firm in the market which determines the overall character of the value chain.

The last approach will be Porter's (1995) approach where he describes the chain as the activities that an organisation performs and links it to the organisations competitive advantage. As part of Porter's approach, he identified five competitive forces which interact within a given industry. These five forces are the intensity of rivalry among existing competitors, the barriers to entry for new competitors, the threat of substitute products and services and lastly the bargaining power of both suppliers and buyers.

The beef value chain depicted in Figure 2.2, for both the domestic and the global markets, shows the various frameworks and regulation conditions for the value chain of beef production. In Figure 2.2 below, one can see that the food laws and regulations, as well as food control and customs, do play an important role in the exporting market. That is why traceability is a requirement that needs to be implemented through the whole value chain, as the movement of a product is interlinked in a chain of role-players. It is thus important for all the role-players to work together to achieve the desired results, as the product moves through the chain.

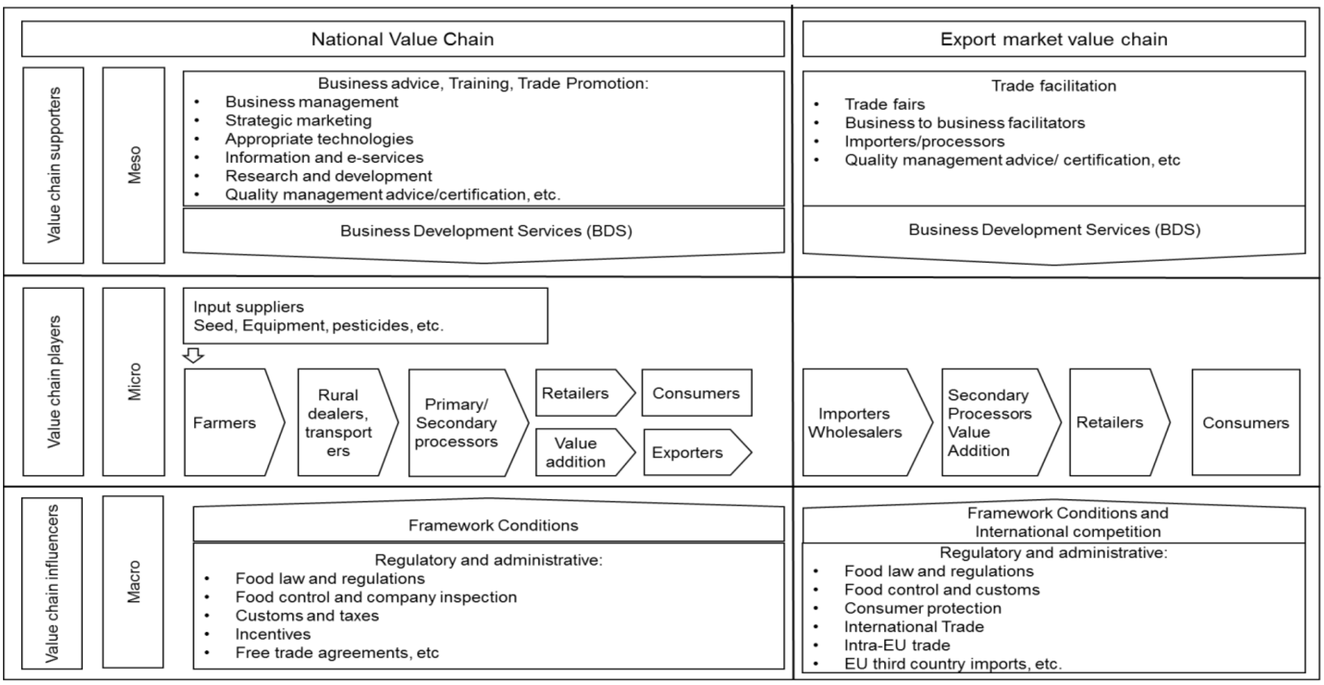


*Figure 2.2: Domestic and Global Value Chain for Beef Products*

Source: Will (2004) and Roduner (2005)

Rhodes, Dauve and Parcell (2007) summarised the marketing channel value in a way that is very similar to the value and supply chain, as seen in Figure 2.3. The biggest difference between them is that the value chain and supply chain do not show how information and money will flow, while the marketing chain does show the importance of the exchange of information throughout the whole value chain. As a product moves from the farm to the consumer, it is important that information about the product, as well as the quality of the product, can flow from the farm to the consumer. At the other end, the payment for the product, as well as information on consumers' preferences, will flow from the consumers back to the farmers.

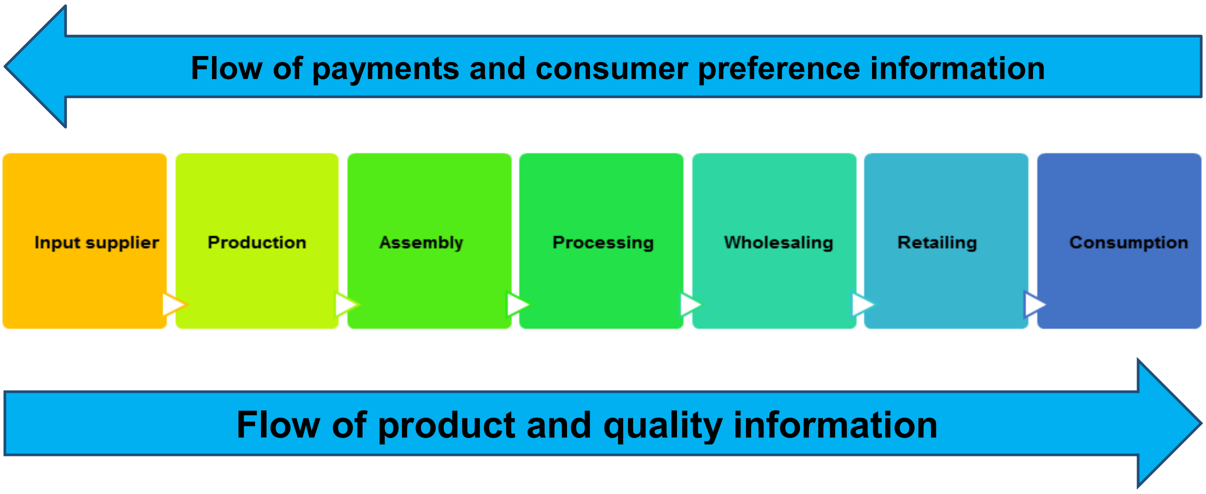



*Figure 2.3: Marketing Channel of Agricultural Products*

Source: Rhodes, Dauve and Parcell (2007).

## 2.6 What is traceability

### 2.6.1 Definitions of traceability

Various definitions can be found in the literature on traceability, and these definitions have changed a lot over the years.

Animal identification is a crucial part of the traceability system. Therefore, it is important to understand what animal identification entails. "An animal identification system is the inclusion and linking of components such as identification of establishments or owners, the persons responsible for the animals, movements and other records with animal identification", as defined by the World Organisation of Animal Health (OIE). The OIE also defines traceability as follows: "the ability to follow an animal or group of animals during all stages of life" (Bowling *et al*., 2008).

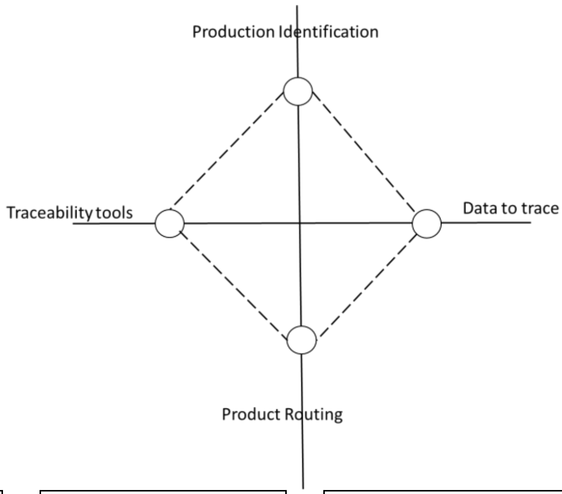
The best explanatory definition of traceability was established by the European Union and can be found in the European General Food Law: "the ability to trace and follow food, feed, food-producing animals or substances intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution." (EU Food Traceability Factsheet, 2007). Therefore, these definitions are very similar to each other, with the OIE's definition being more focused on live animals alone, while the EU's definition focuses on all products from the live animal to processed foods. It is also important to understand that this definition is broad and includes non-food products.

One of the other more unspecific definitions of traceability was established by the International Standardization Organization (ISO) which defined traceability as "the ability to trace the history, application or location of an item or activity by means of recorded identification. When considering product traceability, it can relate to the origin of materials and part, the processing history, and the distribution and location of the product after delivery" (Arisland and Kjærnsrød, 2005). Definitions very similar to that of the ISO definition, which is also used regularly in literature, are the definitions in the Codex Alimentarius, where traceability is defined as "the ability to follow the movement of food through specified stage(s) of production, processing and distribution." These definitions all share the basic aspect of traceability, which is to trace the history of a product. The ISO definition is broad and applies to all products, while the definition in the Codex Alimentarius is more focused on food. Some authors have also established their own definitions of traceability which are very broad, for example: "A record keeping system designed to track the flow of product or product attributes through all stages of production, processing and distribution" (Golan *et al*., 2004). The biggest difference between the definitions of Golan *et al.* (2004) and the Codex Alimentarius is that the *Golan et al.* (2004) definition refers to a traceability system as a record-keeping system, thus a synonym for traceability is record-keeping. Many other definitions can be found in literature which are very similar to the above-mentioned definitions (Dickenson, Hobbs and Bailey, 2003; Smith *et al*., 2008; Dessureault, 2006).

### 2.6.2 Important aspects of traceability

Bechini *et al*. (2008) stated that traceability in practice is achieved only if businesses keep records of all their suppliers, as well as consumers, and then exchange the relevant information along the entire supply chain.

Regattieri *et al*. (2007) identified four important pillars of traceability, being product identification, data to trace, product routing, and traceability tools, as explained in a proper manner by the framework for traceability.




| Product identification | Data to Trace | Product Routing | Traceability tools |
|---|---|---|---|
| Dimensions | Number | Production cycles | Compatibility vs product |
| Volume | Typology | Activities | Compatibility vs process |
| Weight | Degree of detail | Load times | $N^{\circ}$ of data readings |
| Surface Conditions | Dynamism | Equipment | $N^{\circ}$ of data writings |
| Shortness | Data storage requirements | Manual operations | Degree of automation |
| Perishability | Confidentiality and publicity | Automatic operations | Data accuracy |
| Packaging | Checks & alarms | Movement systems | Data reliability |
| Cost | | Storage systems | Company's knowledge |
| Life cycle length | | | Cost of system |
| Bill of material structure | | | |

*Figure 2.4: Framework for Food Traceability*

Source: Regattieri *et al.* (2007)

Golan *et al*. (2004) identified three main characteristics of a traceability system, which are breadth, depth and precision. Breadth is about the amount of information a traceability system records. Depth is how far back and how far forward a traceability system can track a product or animal. Lastly, precision is the degree of assurance with which the tracing system can pinpoint a particular food product's movement or characteristics.

It is important to distinguish between internal and external traceability. "Internal traceability requires that food processors or distributors track internal inputs that change the identity or configuration of the product they are selling." (Miller, 2013). This is rather a reflection of good manufacturing practices rather than actual traceability. An example of internal traceability can be seen in Figure 2.5 (Miller, 2013).

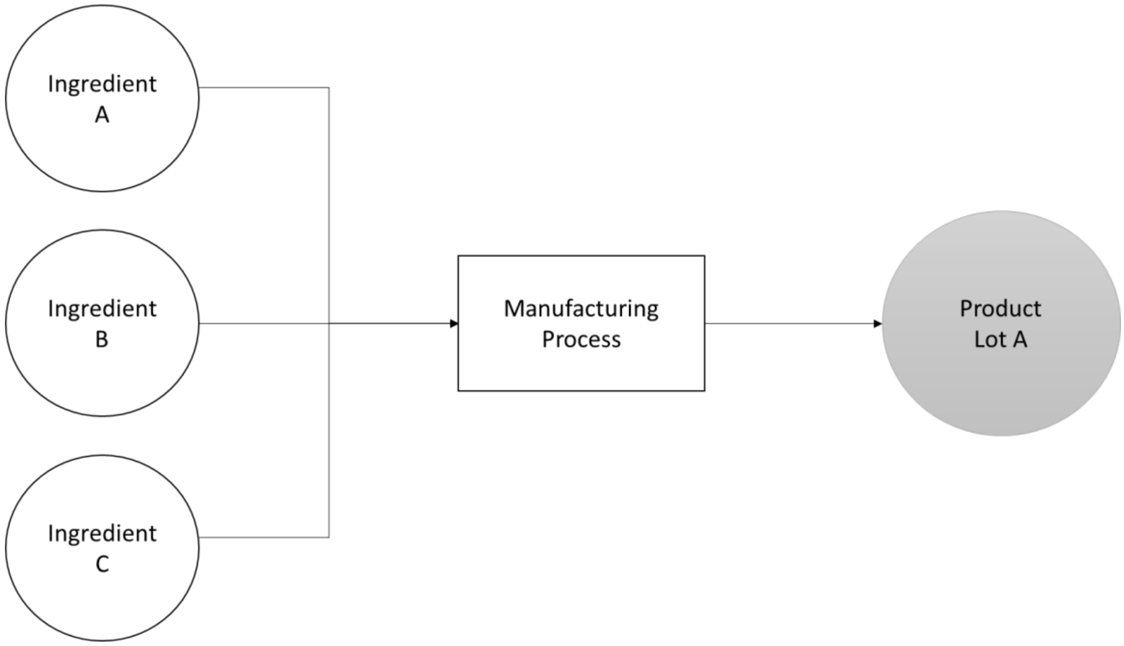



*Figure 2.5: Example of Internal Traceability*

Note: A Food manufacturer produces a product from three ingredients. These inputs are recorded and related to Lot A of the finished product.

Source: Miller (2013)

While internal traceability is only recorded within a company, external traceability is the opposite. External traceability, as represented in Figure 2.6, represents those transactions between various role-players in the supply chain such as growers, processors, distributors, shippers, brokers and brand owners. For external traceability to be effective, it is important that all these segments participate (Miller, 2013).

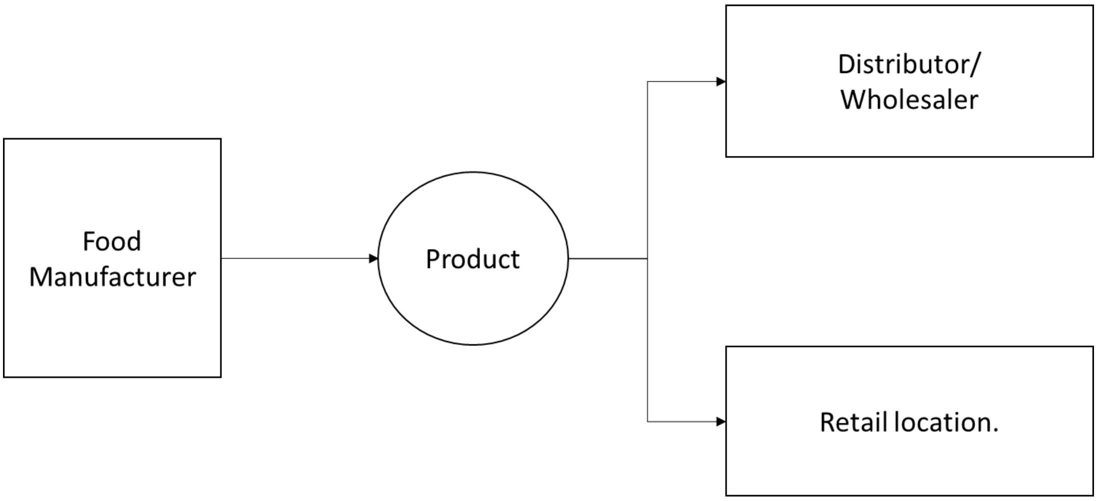



*Figure 2.6: Example of External Traceability*

*Note: A food manufacturer produces a product and tracks the distribution of that product to a distribution and retail location.*

Source: Miller (2013).

Britt *et al*. (2013) identified nine important elements that a modern animal identification and traceability system should have. These nine elements are:

- An establishment registration system
- When groups of animals are not expected to remain intact within the production chain, defined means of physically identifying animals or groups of animals.
- Defined movement documentation requirements
- An official secure database or network of databases where records are kept
- An event and movement recording system that records the establishment-to-establishment movement of animals
- Business rules and associated legal and quality assurance frameworks
- An ongoing and appropriately resourced programme to educate industry participants about their responsibilities and to provide training and technical support
- Documented arrangements for performance monitoring, enforcement, evaluation and periodic review.

- A query system that enables the history and whereabouts of individuals or groups to be elucidated with ease and displayed in conjunction with spatial and temporal information.

### 2.6.3 Reasons for the implementation of traceability

Caporalo *et al.* (2001) have stated that the reasons for the implementation of trace-back systems was to facilitate surveillance, to provide information for the control of certain diseases, and to protect animal health. The aim is not only to trace high-risk animals or products to prevent problems from occurring, but also to enhance quality assurance to the consumer.

Rich *et al*. (2009) identified the exclusion of emerging countries as a huge problem. Some of the reasons for the exclusion were also mentioned. These included the emergence of strict vertical coordination relationships and supermarket procurement systems. Some other reasons mentioned where the increasing specification standards in terms of health, hygiene and product quality standards.

According to Trevarthen (2006), there is a worldwide trend towards improving systems because of the impetus of disease incidents, such as mad cow disease. The European Union decided to make traceability a requirement in the 1990s to track animals during their entire lifecycle in an effort to prevent such illnesses from spreading. Trevarthen also stated that traceability in the food supply chain is even more important in the current global environment than it was in the past.

Hobbs (2006) stated that traceability has become an important tool in the agri-food sector. Consumers' demands for traceability have increased, as the amount of food scare incidents have increased. The demands for differentiated food products have increased. An increase has also been seen in the innovation of better quality measurements, as well as tracking and information management tools. These are some of the drivers that have pushed traceability to the forefront of the supply chain in food products.

Businesses use traceability to comply with certain preconditions for managing the supply chain, for example in meeting consumers' expectations in regard to quality and safety, in increasing the efficiency and speed in the supply chain, and lastly, in managing the physical flow of products within the supply chain (Leat, Marr and Ritchie, 1998).

Buhr (2003) asked a group of participants in a study he had done why they had decided to implement traceability, and the first responses of all the participants were the same: “Consumers demanded to know where their food came from and how it was produced”. In his study, he also referred to traceability as a tool to protect certain brand attributes, such as organic and free-range. Other main drivers for traceability adoption found by Buhr (2003) were larger production uncertainty, higher chances of moral hazard and opportunistic behaviour, increasing quality monitoring costs, and lastly the inability to identify traits without traceability.

Golan *et al*. (2004) identified three main objectives for the implementation of traceability and each of these objectives has its own benefits. These objectives include traceability for supply management, traceability for food safety, and lastly traceability to differentiation and marketing foods with credence attributes. Other motives for the implementation mentioned by the same authors include the protection of property from theft or loss, the control of the spread of diseases, and the proof of certain attributes which might assist in the negotiation of higher prices.

Stranieri, Cavaliere and Banterle (2015) identified three main incentives for the adoption of traceability, namely market-based incentives which can be subdivided into monetary and non-monetary incentives, supply chain incentives which can be subdivided into supply chain transparency, information thoughtfulness and improvement of liability along the supply chain. The last main incentive can be subdivided into normative requirements and international compliance requirements.

Coff, Barling, Korhals and Nielson (2008) described five key objectives for the adoption of traceability in the food industry. These key objectives, as seen in Table 2.6 below, are risk management and food safety; control and verification; supply chain management and efficiency; provenance and quality assurance of products; and lastly, information and communication to the consumer. These key objectives can also be seen as possible solutions for current issues in the South African beef industry.

*Table 2.6: Objectives of Traceability in the Food Industry.*

| Traceability objectives | Description |
|---|---|
| **Risk management and food safety** | Risk assessment: Mapping of foods and feed, food ingredients and processing technologies that have food safety implications for example hygiene.<br>Food residue surveillance: Food sampling at appropriate points testing for residues for example pesticides.<br>Public health recall systems: identification of breakdowns in food safety along the food supply chain, allowing recall of contaminated products for the purpose of protecting public health |
| **Control and verification** | Surveillance and auditing of producer and retailer activities<br>Avoidance of fraud and theft: control of products by chemical and molecular approaches (biological 'food prints ;)<br>Identification of responsible actors but also claims innocence<br>Ingredients definition<br>Avoidance of negative claims for example that a product contains genetically modified organism (GMO) traces. |
| **Supply chain management efficiency** | Cost effective management of the supply chain<br>Computerised stock inventory and ordering systems linked to point of sale<br>Just in time delivery systems<br>Efficient use of resources (cost minimisation) |
| **Provenance and quality assurance of products** | Marketing of health, ethical and other claims<br>Authenticity: identity of the product (food authenticity) and the producer<br>Typically as with European Schemes for Protected Destinations (PDO) and Protected Geographical Indication (PGI)<br>Quality assurance of standards at different stages of production and or Processing for example environmental protocols for production<br>Final product quality assurance |
| **Information and communication to the consumer** | Transparency of the production history<br>Facilitation of informed food choice, through transparency and the ability to compare different products<br>Recognition of specific consumers concerns and information demands- where such concerns and demands are not static but may evolve<br>Public participation: consumer services, companies' 'care lines' and consultation to obtain consumer feedback. |

Source: Coff, Barling, Korhals and Nielson (2008)

## 2.7 Traceability conceptual frameworks

Various conceptual frameworks exist for traceability. Some information on these frameworks can be found in literature, although on some of these frameworks, information is scarce. There is no common theoretical framework for the implementation of traceability, as stated by Karlsen, Dreyer, Olsen and Elvevoll (2013).

### 2.7.1 The TraceFood Framework

Storøy, Thakur and Olsen (2012) did an extensive review on the TraceFood Framework and on the important components of this framework. This Framework consists of six important components, which include the principle for unique identification, principle for documentation of joining and splitting of units (Transformation), generic language for electronic interchange (TraceCore XML), Sector-Specific language for electronic interchange, Sector Specific guidelines for implementation (GTP), and generic guidelines of implementation (GTP).

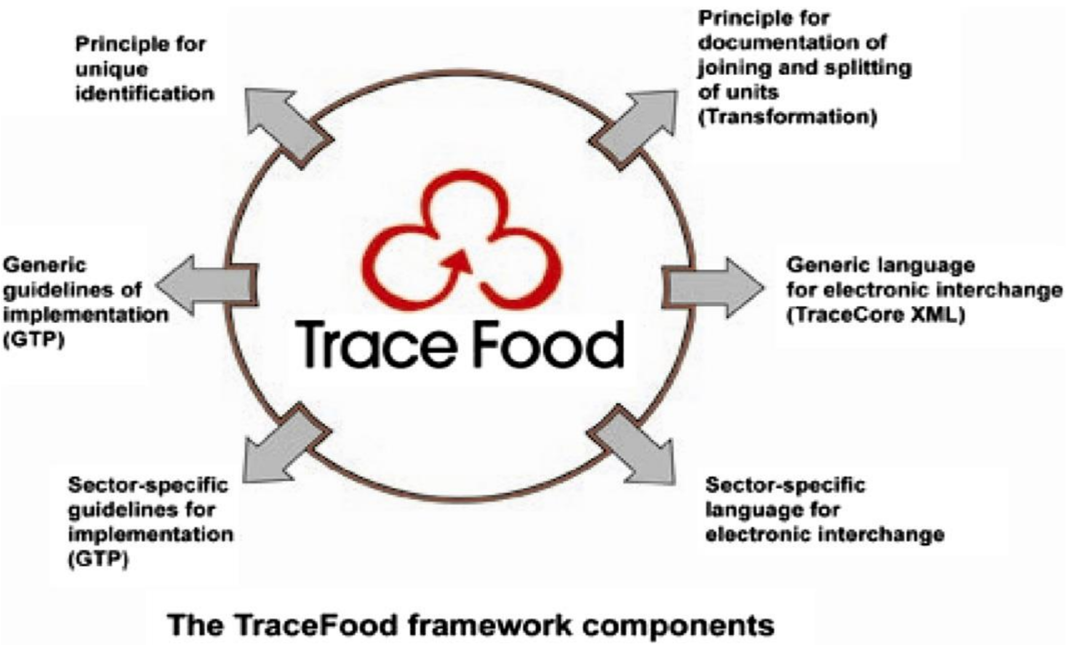



*Figure 2.7: TraceFood Framework Components*

Source: Storøy, Thakur and Olsen (2012)

Unique identification is one of the main requirements in the TraceFood framework. A second requirement is that a minimum amount of information on a traceable unit should be collected through its lifetime. GS1 standards and the GS1 numbering system are used in the unique identification of Trade Units (TUs) and Logistic Units (LUs). Documentation regarding transformation is of utmost importance because it is important to keep track of all splitting or transformations of a trade unit in order to track and trace the product, when necessary. Various steps have been established to ensure that a specific TU can be tracked or traced, starting with defining the trade unit for the specific business under examination. Secondly, the unique ID of the TU should be recorded, and in cases where no Unique ID exists, one should be allocated. It is important that all the IDs and TUs dispatched should be recorded.

Two types of messages exist in any electronic information interchange of a product, namely a request for data and a response to that request. For the TraceFood framework, the TraceCore eXtensible Markup language was developed in an effort to establish a standard method for exchanging data. Clear and unambiguous information interchange is very important in any sector. Each sector should specify how certain properties should be measured, as well as what they should be called. That is why it is important to have sector-specific standards for properties and the values which form part of a specific sector. A parameter list is included in the generic guidelines for the implementation of traceability. The data that should be recorded as stated in the parameter list include producer ID, Trade Unit, etc.

Badia-Melis *et al*. (2015) compared the TraceFood Framework and the Food Track and Trace Ontology in a recent study. In this study, the base, focus and various parts of each of these conceptual frameworks were compared, as seen in Table 2.7 below.

*Table 2.7: FTTO and TraceFood Framework*

| | **FTTO** | **The TraceFood framework** |
|---|---|---|
| **Base** | Unique body of knowledge | International standard |
| **Focus** | Focusing on sources of information | Focusing on electronic information for data exchange |
| **Parts** | Agents involved in any process<br>Food product, raw or manipulated<br>Service product, which has any intervention in the food life<br>Process that the food has suffered | Unique ID<br>Documentation of product transformation<br>Generic and specific language for e-exchange information<br>Generic and specific guidelines for traceability implementation. |

Source: Badia-Melis *et al*. (2015)

Badia-Melis *et al*. (2015) concluded this comparison by stating that both the Food Track and Trace Ontology and the TraceFood Framework are focused on the management of information, and the only difference is the way in which information management occurs.

### 2.7.2 The Food Track and Trace Ontology

As stated by Badia-Melis *et al*. (2015): "Ontology is an explicit formal specification of terms in the domain and relations among them, supports the management of a unique body of knowledge through the integration of different concepts and terms coming from heterogeneous sources of information and users involved in the supply chain".

The Web Ontology Language (OWL) of Smith *et al.* (2004) is used for the FTTO. The OWL vocabulary has an important feature required for the FTTO, which is its extreme richness for describing relations among classes, properties and individuals.

The FTTO ontology consists of four main classes, which are agents, food product, service product and process. Agents represent an entity, a company or individual that is involved in the management of a food product. Examples of agents include primary producers, processors, distributors and transporters. The food products in the FTTO include ingredients such as salt and sugar. The food products also include raw materials which will be further processed into final products. On the other hand, service products are those products which are used in the manipulation of raw and unprocessed products, for example packaging, food colouring, and food additives. Processes include all the processes included in the agro-food processes, as well as all business processes needed to manufacture the final product (Pizzuti *et al*., 2014). There are also five main activities that play an important role in the conceptualisation that is required in the developing each module. These activities are identification of class and their classification, identification and description of data properties, identification and description of object properties, identification of instances and their description, and lastly, validation of the previous step. These steps being taken into consideration, Pizzuti *et al.* (2014) also put 12 steps into place for the building process of the FTTO.

A FTTO building process consisting of 12 steps can be seen in Table 2.8 below.

*Table 2.8: FTTO building process*

| **Step 1** | **Analysis of the existing ontology in the food domain for reusing** |
|---|---|
| **Step 2** | Extraction of the relevant information for the food traceability domain |
| **Step 3** | Collection of the nouns related to the food and to the agro-food processes (identification of concepts) |
| **Step 4** | Definition of modules |
| **Step 5** | Definition of classes' hierarchy |
| **Step 6** | Definition of Data Properties to describe classes |
| **Step 7** | Definition of object properties to describe the internal structure of concepts |
| **Step 8** | Definition of individuals |
| **Step 9** | Definition of cardinality constraints and values restrictions |
| **Step 10** | Connection of the different modules to the top-level ontology |
| **Step 11** | Performing of the reasoning |
| **Step 12** | Translation of the ontology schema in OWL language |

Source: Pizzuti *et al.* (2014)

### 2.7.3 Critical Tracking Event and Key Data Element framework

The IFT's (Institute of Food Technologists) current definition for a Critical Tracking Event (CTE) is:

> "A CTE is any occurrence involving an item at a specific location and time associated with collection and storage of data useful for associating the item (or related items) to the specific occurrence at a later time and is determined to be necessary for identifying the actual path of an item through the supply chain" (Welt and Blanchfield, 2012).

Miller and Welt (2014) divided critical tracking events into four main categories which would comply with various parts of the value chain. These categories include terminal CTEs (these events exist at the terminals of a supply chain, for example cooling, washing and sorting), aggregation/disaggregation CTEs (these events precede terminal CTEs, for example packaging), transfer CTEs (this is when any movement of the product in the supply chain occurs (for example, loading on the truck and shipping), and commingling CTEs, which occur when a new product is formed and when various products from different sources are combined.

Miller (2013) did a comparison between the critical control points which form part of HACCP and Critical Tracking Events (CTEs) and what is required at each of them. In Table 2.9 below, one can see clearly that the frameworks are very similar.

Table 2.9: Comparison of Hazard Analysis and Critical Control Points (HACCP) and Critical Tracking Events (CTEs)

| **HACCP** | **CTEs (Product Tracing** |
|---|---|
| **Conduct a hazard analysis** | Identify products and product inputs to be traced |
| **Identify critical control points** | Identify critical tracking events |
| **Determine critical limits** | Determine key data elements |
| **Establish monitoring procedures** | Establish data collection procedures |
| **Establish corrective actions** | Establish data storage procedures |
| **Establish verification procedures** | Conduct mock trace backs |
| **Ensure recordkeeping** | Maintain a written record of the product tracing plan |

Source: Miller (2013)

The generic framework as shown in Table 2.10 below summarises the critical tracking events and key data elements that can be used in any value chain for any of the role-players (Zhang and Bhatt, 2014).

*Table 2.10: Updated Generic Framework of Zhang and Bhatt (2014)*

| **Key data Elements** | | **Critical Tracking Events** | | | |
|---|---|---|---|---|---|
| | | Creation | Transportation | Transformation | Depletion |
| | | Harvest, hatch, grow, catch | Load, fill, order, ship, return, transport, receive, unload, store, warehouse | Process, Production, package, batch input or output, separate, sort, combine, mix, repack, comingle, rework | Sell to consumer, consumption, discard, dispose, lose |
| **Who** | Event owner | X | X | X | X |
| | Trading Partner (Supplier, customer) | | X | | |
| | Trailer, Carrier, Transporter | | X | | |
| **What** | Item, Good, Product, | X | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| | Commodity, Variety, Packaging type, Packaging materials, Packaging style, Batch, Lot Code, Sell-by or Use-by Date, Quantity, Unit of measure | | | | |
| **When** | Date, Time | X | X | X | X |
| **Where** | Origin, Event Location, Product Source, Product Destination | X | X | X | X |
| **Link** | Activity, Bill of Lading, Invoice, Packing Slip, Load information, Farm Ticket, Purchase order, Work order | X | X | X | |

Source: Zhang and Bhatt (2014)

## 2.8 Traceability systems in other countries

Most of the bigger importing and exporting countries of beef have introduced traceability systems, for various reasons. These systems are very similar to a certain extent, while they also differ in some ways. It is important to study these systems to get an idea on what the basis is for a traceability system, whether voluntary or mandatory.

Various authors (Souza-Monteiro and Caswell, 2004; Smith *et al*., 2008) have summarised the systems of various beef-exporting countries and economic union. Souza-Monteiro and Caswell (2004) summarised the various countries by means of depth, breadth and precision, while Smith *et al*. (2008) only summarised the status of the traceability system, and on which parts of the value chain it is applied to.

Each of the countries and economic union mentioned below will be discussed in more in depth in Article 1, set out in Chapter 4, where a detailed overview was done on beef traceability, globally.

### 2.8.1 Traceability in the European Union

Two different types of traceability exist in the European Union. The first is a supply chain traceability system, based on an information procedure which aims to identify the economic agents who play an important part in the supply chain. This system is a mandatory system that regulates the supply chain. The second traceability system is a voluntary traceability system that is more complex. This main aim of this system is to give a higher level of food safety in a supply chain system that can ensure better quality. The specifications for the mandatory system can be found in the General Food Law, while the specifications for the voluntary system make reference to national and international standards that exceed the General Food Law (Stranieri *et al*., 2015).

The European Union put regulations into place for traceability in 2000, which assisted in the establishment of a mandatory traceability system. The main aims of Regulation (EC) 1769/2000 are to establish a system that identifies, registers and labels all beef products, as well as bovines. The EU system consists of two main objectives, the first of which is to establish a system that is efficient and assists in the identification and registration of bovines at all stages of production. The second objective is to define a common labelling system for the European Union for the beef sector (Souza-Monteiro and Caswell, 2004). In the study done by these two authors, they distinguished between the mandatory and voluntary labelling systems, which are the same as the two types of traceability systems as explained by Stranieri *et al*. (2015).
If the European Traceability system is evaluated against the three main characteristics of traceability, namely breadth, depth and precision, the results might be seen as interesting. The European mandatory traceability system's breadth is narrow, therefore the voluntary traceability system can be used to improve the breadth, depth and precision so as to comply with the demands of retailers and consumers. DNA testing is a good tool that can be used to improve the precision of the traceability

system, but the only problem with DNA testing is that it is quite expensive (Souza-Monteiro and Caswell, 2004).

In January 2005 with the introduction of Article 18, the European Commission mandated all food businesses to adequately label all marketed food products to facilitate traceability (Schwagele, 2005).

Individual birth-to-retail traceability is implemented in the European Union and an animal can be traced from the farm, through processing, to the retailer as the individual ID of the animal is put on the label of the finished product. In cases where more than one animal are packed together, the various IDs are put in batches which can then be traced back to the individual animals. Birth-to-retail traceability is not used that often in the European Union, but rather birth-to-slaughter (Jensen and Hayes, 2006).

### 2.8.2 Traceability in Brazil

In 2002, the Brazilian System of Bovine and Buffalo Identification was created by the Brazilian Ministry of Agriculture, Livestock and Food Supply. For a producer to comply with this law, it is important that all bovines and buffalos, produced domestically or imported, should be individually identified, registered and monitored throughout production. These regulations do not apply to producers who only produce for the domestic market, but only for those who produce beef specifically for the export markets. Brazil's electronic database is kept and managed by the Secretary for Animal and Plant Safety. The information on the database has to be updated each time an animal moves. If the Brazilian system is evaluated against the three characteristics, it is clear the system has less depth than those of Japan, Australia and the EU states, but does have the same breadth and precision as those countries and economic union (Souza-Monteiro and Caswell, 2004).

### 2.8.3 Traceability in Australia

Australia started the implementation of a traceability system on a voluntary traceability system even before the European Union introduced traceability. After the implementation of the National Livestock Identification System (NLIS) in 2003, traceability became mandatory. Australia's main motivation for the implementation of a mandatory traceability system is to support and enhance Australia's competitiveness in the beef export market, as well as to reduce the risks and economic impacts of potential animal disease outbreaks in the future. The NLIS system is an electronic system, with electronic ear tags or rumen boluses being used to identify each animal and record and store relevant information on that animal. All information, such as animal movement, production information and animal health information, is recorded and stored on the national database. The Australian traceability system has very good depth from the farm to the export port, but is not compatible with the systems of Japan and the European Union, while it is very similar in breadth to the Japanese system. The Australian system has very good precision and can trace back to an individual animal without the use of DNA analysis (Souza-Monteiro and Caswell, 2004)

Australia, as with the European Union, has a mandatory as well as a voluntary traceability system in place. The voluntary traceability system focuses on certain quality assurances, such as grass fed and grain fed beef, and this system is based on ISO 9002 and also takes HACCP into account (Meat and Livestock Australia, 2002).

### 2.8.4 Traceability in the United States of America

Various traceability systems and frameworks exist in the United States of America, as traceability is voluntary. Some of these systems are promoted by government, and the most well known is the Country of Origin Labelling (COOL) system. In recent years, both private companies and public authorities have been promoting the implementation of a traceability system (Souza-Monteiro and Caswell, 2004).

### 2.8.5 Traceability in Canada

Canada does not have a full mandatory farm-to-fork traceability system in place, but farmers must identify animals when they are moved from the farm. The Canadian Traceability system is managed by the Canadian Cattle Identification Agency (CCIA), and is known as the Canadian Identification System, which came into place in 2001. The Canadian Traceability system is lacking in depth, as compared with those of Japan and the European Union. This system does not allow for a product to be traced back to the farm of origin.

### 2.8.6 Traceability in Argentina

In February 2003, Argentina introduced a mandatory Export Cattle Identification System in accordance with Resolutions 001/2003 and 002/2003. Each animal produced for the export market that originates on a farm or feedlot needs to be identified. The Argentinian system is not that precise, as there is no central database and it relies on information provided by producers. The Argentinian system is deeper than that of Brazil, but not as deep as those of Australia, the EU and Japan, and the same applies to its breadth (Souza-Monteiro and Caswell, 2004).

### 2.8.7 Traceability in Japan

In Japan, there are certain basic requirements built into their domestic traceability system. These requirements are that animals should be identified with an ear tag that has the animal's unique identification number on it. This number should be linked to other information recorded on the animal, as required by the Japanese food safety regulations. This information covers the breed of the animal, the sex of the animal, and the production history of the animal, which includes information of feed used in the production process. If Japan's system is evaluated against the three characteristics of a traceability system, it is clear that the Japanese system is very similar to that of the European Union, especially with regard to depth. The Japanese system is a bit deeper than that of the of the European Union, as consumers have access to more information surrounding the production of beef, such as the date and place of birth, the sex of the animal, the breed of the animal and the production history, and as all that information is recorded, it improves the breadth of the system. The precision of the Japanese system is a bit better than that of the European Union, as DNA is used to track back to the individual animal (Souza-Monteiro and Caswell, 2004).

Fitzpatrick (2003) has stated that Japan's traceability system consists of four levels. Level 1 comprises tagging a live animal and taking a DNA sample from the animal, either alive or at slaughter. In level 2, a 10-digit code that corresponds to the animal's ear tag will be linked to the animal's DNA sample. In level 3, all the animal's health and feeding information should also be added to the database held by the Japanese Ministry of Agriculture, Forestry and Fisheries. In the last level, that same 10-digit code is linked to all offal and muscle derived from that animal, and the link should be kept through all stages of processing and distribution.

According to Clemens (2003), it is possible for consumers to track packed beef from purchase back to the farm where it was produced and to retrieve all relevant information by using an in-store computer or the internet from home.

## 2.9 Global traceability standards and regulations

### 2.9.1 Shortcomings in current traceability systems

According to Golan *et al*. (2004), “There are two distinct sets of traceability systems existing: one for live animals and another for meat. The challenge the industry faces now is to coordinate and link many disparate animal and meat traceability systems and develop a standardized system for identifying farm-level, live-animal attributes in finished meat products.”

A possible shortfall in the traceability system of the European Union as identified by Souza-Monteiro and Caswell (2004) is at the cutting plants. Currently links are only established with groups of animals and not individual animals. This have a negative impact on the precision of the system as the precision is not as exact as it would have been in the case where it was linked to the individual animal.

Most of the existing traceability systems and regulations are based on the concept of one forward and one backward (OFOB) traceability, which is also known as one-up and one-down (OUOD). One of the main reasons why this approach is so popular is because it only requires customary business records and no other records. OFOB also does not require much additional investment, but this approach is slow, ineffective and inefficient for investigators, which may result in unsolved outbreaks (Miller, 2013).

## 2.10 Consumers’ perceptions and requirements of traceability

Buhr (2003) asked participants in a study he had done why they had decided to implement traceability, and the first responses of all the participants were the same: “consumers demanded to know where their food came from and how it was produced”.

In his study, he also referred to traceability as a tool to protect certain brand attributes such as organic and free-range.

There is a big difference between the European and the US consumers in their perceptions of what food safety and quality attributes are important. According to the European Union food labelling policies, there is much more emphasis and focus placed on traceability, origin and production processes, than in US policies (Buhr, 2003; Bureau and Valchenchini, 2003).

In a study done by Loureiro and Umberger (2007), they calculated US consumers' willingness to pay for various attributes in steak. The results of the study showed that country of origin labels carry a positive premium of $ .565 per pound, while traceability to farm production carried a lower premium of $1.8999 per pound. This is similar to other studies done (Lusk and Anderson, 2004, Tonsor *et al*., 2005).

Dickenson and Bailey (2002), as well as Hobbs (2003), found that consumers placed the highest relative value on food safety certification.

## 2.11 Benefits for the adoption of traceability.

### 2.11.1 Major factors affecting benefits of traceability.

Six factors were identified by Golan *et al*. (2004) that could affect the benefits of traceability. These factors are the following:

- The higher the value of coordination along the supply chain is, the larger the benefits of traceability for supply-side management will be.
- The larger the market is, the larger the benefits of traceability will be for supply side management, safety and quality control, and credence attribute marketing.
- The higher the value of the food product is, the larger the benefits of traceability for safety and quality control will be.
- The higher the likelihood of safety or quality failures is, the larger the benefits will be in reducing the extent of failure with traceability systems for safety and quality control.

- The higher the penalties for safety or quality failures are, where penalties include loss of market, legal expenses, or governmental mandated fines, the greater the benefits will be in reducing the extent of safety or quality failures with traceability.
- The higher the expected premiums are, the larger the benefits of traceability for credence attribute marketing will be.

### 2.11.2 General benefits for the implementation of traceability found in literature

Meuwissen *et al.* (2003) identified increased transparency, reduced exposure to liability, improved effectiveness, price premiums, improved internal efficiency, and reduced transaction costs as being all possible benefits for role-players who decide to implement traceability. These authors also indicated that they believe that much uncertainty is involved with the benefit to producers of consumers' paying a price premium for food safety-related systems and certification schemes.

Other general benefits include increased supply chain efficiency, improved information management, the differentiation of quality attributes, and lastly, the distribution of liabilities among agents in the supply chain. These authors also divided the incentives for the adoption of traceability into two groups, namely monetary incentives and non-monetary incentives. Monetary incentives include firms' productivity, HR management, and an increase in the firm's profits, while non-monetary incentives include food safety, food quality, protection of a company's reputation, and commercial pressure (Stranieri *et al*, 2015).

### 2.11.3 Benefits for the National Livestock Traceability system (NLTS) in Canada.

Hobbs, Yeung and Kerr (2007) identified the benefits on the NLTS in Canada and divided them into five groups, namely risk reduction, production management, supply chain management, market enhancing, and governance. Under each of these groups, the authors identified specific benefits, totalling twenty-three benefits. Disease management, incentives for good practice, trade and market access public health, in-time management information, reduced incentives to cheat, product differentiation, and information for research are only a few of these benefits.

### 2.11.4 Benefits for the adoption of National Animal Identification System (NAIS) in the USA

The following benefits of the implementation of the NAIS system can be found in an overview report (2009) by the Animal and Plant Health Inspection Service, U.S. Department of Agriculture. The following benefits are mentioned:

- Enhancement to animal health surveillance and disease eradication
- Reduction of economic impact of disease outbreaks
- Reduction of cattle producers’ animal disease testing costs
- Re-opening export markets: Foot and Mouth Disease simulations
- Regionalisation and compartmentalisation to re-establish market access.
- Enhancement of global competitiveness
- Increased transparency in the supply chain
- Improvement of value-added and certified programme efficiency
- Enhancement of animal welfare in response to natural disasters
- Reduction of risk of unfounded liability claims
- Minimising damage to individual producers and industry as a whole.

### 2.11.6 Benefits for farmers in the adoption of traceability

The benefits of on-farm traceability include the enhancement of animal health and disease control, reduction in the economic impact of disease control, enhancement of efficiency in animal testing, increased transparency in the supply chain, and increased differentiation of products, for example grass-fed beef, as well as possible price premiums that could be paid to farmers who have good traceability records (Trautman, Goddard and Nilsson, 2002). Other benefits as found on the NLIS website include the receiving of carcass feedback for the farmer and the linking of individual animal's performance that could enhance genetic decision-making, which might ensure better carcasses. The other big benefit is that lost or stolen animals can be traced back to their owners when found. Hobbs, Yeung and Kerr (2007) believe that another benefit of traceability implementation is that it reduces a farmer's incentive to cheat about the age of the animal or about the medical records of the animal, as well as bringing insurance benefits due to savings in premiums. Other benefits include more trust being generated throughout industry, which would improve the operating atmosphere. Traceability also helps to increase a farmer's efficiency, which is important as it is well known that farmers should use their scarce resources wisely (Fisher, 2015).

#### 2.11.7 Benefits for the implementation of traceability at auctions.

Auctions are mostly only a stopover of an animal and therefore the animal only spends a very small amount of time at that premises. The benefits therefore are only few, which include a reduction in information asymmetry on quality and the enabling of the auction to manage the risks surrounding possible disease outbreaks. Therefore, buyers can be assured that they can integrate bought animals into their current herds more easily (Trautman, Goddard and Nilsson, 2008). Other benefits include the improvement of information management, the enhancement of quality attributes thanks to access to important information, and the fact that liability can be distributed better among the role-players in the supply chain (Stranieri, Cavaliere and Bantere, 2016). Meuwissen *et al*. (2003) have identified various benefits for the adoption of traceability, of which increased transparency, better control of livestock epidemics, and reduced exposure to liability can be applied to auctions.

#### 2.11.8 Benefits for the implementation of traceability at feedlots.

There are various benefits in the implementation of traceability for feedlots. According to Fisher (2015), efficiency and risk management are some of the benefits in the implementation of traceability. Therefore, in cases where the right animals are bought in which will perform better in the feedlot, it will decrease waste and therefore increase profitability. Other benefits include the assurance that the animals bought in are healthy, and the prevention of spreading diseases. The risk and liability surrounding possible problems can be detected in time and therefore this could reduce risk and liability (Trautman, Goddard and Nilsson, 2008). Traceability can also assist feedlots in brand-building initiatives and differentiation (Buhr, 2003). The same benefits mentioned by Hobbs, Yeung and Kerr (2007) are applicable to feedlots, which include insurance benefits, improvement of operating atmosphere, and access to real time data which could improve value chain efficiency.

#### 2.11.8 Benefits for the implementation of traceability at the abattoir

With the implementation of traceability, it is possible for abattoirs to reduce the occurrence of recalls and therefore reduce the recall costs for abattoirs. Traceability makes it possible for abattoirs to ensure that the meat is safe and to control the quality. Traceability helps to reduce information asymmetry of the quality of the products. With traceability, the costs of correcting a food safety incident can be reduced in cases where a food safety incident occurs, which is another benefit, and traceability reduces transaction costs coming from the monitoring of upstream suppliers (Trautman, Goddard and Nilsson, 2008). Traceability can be a crucial tool in protecting a specific brand and in ensuring no counterfeiting, as well as in helping with the assurance of specific attributes such as grass-fed or hormone free (Golan *et al*., 2004; Meuwissen *et al*., 2003, Regattieri *et al*., 2007). Real-time data, improved logistics, and improved trust through credibility of quality assurance, such as hormone-free and free range (Hobbs, Yeung and Kerr, 2007).

#### 2.11.9 Benefits for the implementation of traceability at deboning and packaging plants.

Trautman, Goddard and Nilsson (2008) identified various benefits for the implementation of traceability, which include a reduction of transaction costs from monitoring upstream suppliers, as well as a reduction in recall costs because of possible food safety outbreaks. Traceability also enhances supply chain confidence, improves supply chain management, decreases spoilage and waste, and increases consumers' confidence (Fisher, 2015). Rius (2015) stated that another possible benefit for the processors and packers in the Uruguay system comprise improved conditions for valuable certifications. Food safety, public health, improved logistics, reduced incentive to cheat, insurance benefits and the protection of consumers' confidence, as well as quality control and assurance such as the credibility in certain brands, build on certain attributes such as grass-fed, hormone-free, grass-fed and free range (Hobbs, Yeung and Kerr, 2007).

#### 2.11.10 Traceability benefits for consumers, government and society.

Trade-related benefits, as identified by Hobbs, Yeung and Kerr (2007), include the maintaining of market access, the regionalisation of outbreaks, and the preservation of disease control to maintain export markets. Traceability also helps with maintaining consumer confidence and in reinforcing the credibility of an industry. Traceability also helps to protect public health and to ensure food safety, assists interprovincial trade, and helps with better communication along the supply chain. Traceability also assists in the improvement of quality problems and better coordination for disaster response and research to prevent disasters. Trautman, Goddard and Nilsson (2008) identified certain benefits for each of the role-players in a value chain. These benefits include a reduction in cases of foodborne illnesses, a reduction in risks related to the accidental slaughter of contaminated animals, a reduction of medical costs, and a loss of productivity, which are all reductions in societal costs. Traceability can also be used in research to improve industries' quality.

## 2.12 Cost-benefit analyses found in literature

Various studies have been done on the costs and benefits of the implementation of traceability systems. Mus (2006) carried out extensive research on various traceability approaches and a cost analysis for the US beef industry. A cost analysis was conducted for the various role-players that included cow/calf producers, sale yard operations, stocker operations, feedlot operations, packaging plants, slaughterhouses and retailers. Table 2.11 below indicates the cost per head of cattle for different sizes of cow/calf operations, and in that comparison between the different sizes, it is clear that as the size of the enterprise increases, the cost per head of cattle decreases, and thus the adoption of traceability is cheaper. A difference of $60.96 in costs can be seen between a small enterprise with 20 cows and a medium enterprise of 250 cows, while a $4.78 decline in costs can be seen between 250 cows and 2500 cows, which is a smaller decline than with the first comparison.

*Table 2.11: Breakdown of RFID costs for various cow/calf producers in the USA*

| **RFID Components** | **Number of Head** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 20 | 41 | 60 | 125 | 250 | 625 | 950 | 1250 | 2500 |
| **EID Transponder (Tag)** | | | | | | | | | |
| **Allflex FDX EID/Visual** | 3.01 | 3.01 | 3.01 | 3.01 | 3.01 | 3.01 | 3.01 | 3.01 | 3.01 |
| **Electronic Reader** | | | | | | | | | |
| **Allflex stick reader** | 8.30 | 4.05 | 2.77 | 1.33 | 0.66 | 0.27 | 0.17 | 0.13 | 0.07 |
| **Data Accumulator** | | | | | | | | | |
| **HP laptop** | 5.30 | 2.58 | 1.77 | 0.85 | 0.42 | 0.17 | 0.11 | 0.08 | 0.04 |
| **Software/Web based analysis and storage** | | | | | | | | | |
| **Computer Software** | 8.08 | 3.94 | 2.69 | 1.29 | 0.65 | 0.26 | 0.17 | 0.13 | 0.06 |
| **Other** | | | | | | | | | |
| **Internet Access** | 6.15 | 3.00 | 2.05 | 0.98 | 0.49 | 0.20 | 0.13 | 0.10 | 0.05 |
| **Subscription Fees** | 12.81 | 6.25 | 4.27 | 2.05 | 1.03 | 0.41 | 0.27 | 0.21 | 0.10 |
| **Labor** | 25.63 | 12.50 | 8.54 | 4.10 | 2.05 | 0.82 | 0.54 | 0.41 | 0.21 |
| **Total ($)** | **69.28** | **34.34** | **25.10** | **13.62** | **8.32** | **5.13** | **4.41** | **4.07** | **3.54** |

Source: Mus (2006)

For the results shown in Table 2.12 below, Mus (2006) distinguished between the various sizes of sale yard operations, with small operations selling 500 head, and large operations selling 30 000 head of cattle. 7500 head of cattle can be seen as the middle amount, and the difference in cost is $16.54 per head of cattle, while the saving in average cost per animal decreases to $2.09 for 30 000 animals. Therefore, economies of scale do influence the cost for the adoption of RFID technology.

*Table 2.12: Breakdown of RFID Costs for various sale yard operations.*

| **RFID Components** | **Number of Head** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 500 | 1000 | 250<br>0 | 500<br>0 | 750<br>0 | 1000<br>0 | 1500<br>0 | 2000<br>0 | 3000<br>0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **EID Transponder (Tag)** | | | | | | | | | |
| **Allflex FDX EID/Visual** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Electronic Reader** | | | | | | | | | |
| **2 Allflex stick reader** | 0.66 | 0.33 | 0.13 | 0.07 | 0.04 | 0.03 | 0.02 | 0.02 | 0.01 |
| **Data Accumulator** | | | | | | | | | |
| **2 HP laptop** | 0.97 | 0.49 | 0.19 | 0.10 | 0.06 | 0.05 | 0.03 | 0.02 | 0.02 |
| **Software/Web based analysis and storage** | | | | | | | | | |
| **Computer Software** | 0.46 | 0.23 | 0.09 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 |
| **Other** | | | | | | | | | |
| **Internet Access** | 0.25 | 0.12 | 0.05 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 |
| **Subscription Fees** | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 |
| **Labor** | 15.38 | 7.69 | 3.08 | 1.54 | 1.03 | 0.77 | 0.51 | 0.38 | 0.21 |
| **Total ($)** | **19.52** | **10.65** | **5.34** | **3.57** | **2.98** | **2.68** | **2.38** | **2.24** | **2.09** |

Source: Mus (2006)

Stocker operators were divided into nine groups, ranging from 2000 animals up to 50 000 animals, with a total decline shown of $4.85 per head between 2000 animals and 50 000 animals. One can see that there is quite a difference in costs for Stock operators than is the case for cow/calf producers and sale yard operators.

*Table 2.13: Breakdown of RFID cost for various stock operators*

| **RFID Components** | **Number of Head** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 4000 | 8000 | 10000 | 15000 | 20000 | 30000 | 40000 | 50000 |
| **EID Transponder (Tag)** | | | | | | | | | |
| **Allflex FDX EID/Visual** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Electronic Reader** | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Destron Walk-Thru Reader** | 0.73 | 0.37 | 0.18 | 0.15 | 0.10 | 0.07 | 0.05 | 0.04 | 0.03 |
| **Data Accumulator** | | | | | | | | | |
| **2 HP laptop** | 0.97 | 0.49 | 0.19 | 0.10 | 0.06 | 0.05 | 0.03 | 0.02 | 0.02 |
| **Software/Web based analysis and storage** | | | | | | | | | |
| **Computer Software** | 0.46 | 0.23 | 0.09 | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 |
| **Other** | | | | | | | | | |
| **Internet Access** | 0.25 | 0.12 | 0.05 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 |
| **Subscription Fees** | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 |
| **Labor** | 3.84 | 1.92 | 0.96 | 0.77 | 0.51 | 0.38 | 0.26 | 0.19 | 0.15 |
| **Total ($)** | 6.85 | 4.32 | 3.06 | 2.8 | 2.47 | 2.30 | 2.13 | 2.05 | 2 |

(Source: Mus, 2006)

Feedlot operators also differ in size, just like the other operators mentioned above, and the smallest operation mentioned in Table 2.14 below consists of 2000 head of cattle, while the biggest consists of 50 000 head of cattle. The difference in cost per animal starts at a high of $6.85 and decreases by $4.85 to $2 for operations with 50 000 animals. Therefore, one can come to the conclusion that it is more beneficial for larger operations than for smaller operations.

*Table 2.14: Breakdown of RFID costs per head for feedlots*

| **RFID Components** | **Number of Head** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 5000 | 10000 | 15000 | 20000 | 25000 | 30000 | 40000 | 50000 |
| **EID Transponder (Tag)** | | | | | | | | | |
| **Allflex FDX EID/Visual** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Electronic Reader** | | | | | | | | | |
| **Destron walk-thru reader** | 0.73 | 0.29 | 0.15 | 0.10 | 0.07 | 0.06 | 0.05 | 0.04 | 0.03 |
| **Data Accumulator** | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Dell precision comp** | 0.30 | 0.12 | 0.06 | 0.04 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 |
| **Software/Web based analysis and storage** | | | | | | | | | |
| **Computer Software** | 0.12 | 0.05 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 |
| **Other** | | | | | | | | | |
| **Internet Access** | 0.06 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Subscription Fees** | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 | 1.79 |
| **Labor** | 3.84 | 1.54 | 0.77 | 0.51 | 0.38 | 0.31 | 0.26 | 0.19 | 0.15 |
| **Total ($)** | 6.85 | 3.82 | 2.80 | 2.47 | 2.30 | 2.20 | 2.13 | 2.05 | 2 |

Source: Mus, (2006)

*Equation 2.1: gives the equation and results for the total cost of Traceability from farm to fork*

$$Cost\ of\ Traceability\ from\ farm\ to\ fork = (Electronic\ Identification\ Cost) + (DNA\ testing\ cost)$$

$$= \frac{\begin{matrix}(Cost\ for\ Cow\ Calf\ Operator + \\ Cost\ for\ Saleyard\ operator + \\ Cost\ for\ Stocker\ Operdtor + \\ Cost\ for\ feedlot\ operator + \\ Cost\ for\ Packing\ Plant) \\ +(Database\ cost \\ for\ each\ player\ in\ the\ chain)\end{matrix}}{Average\ pund\ of\ beef\ derived\ from\ cattle} + (DeoxyriboNucleac\text{-}Acid\ (DNA)\ testing\ at\ Packing\ Plant\ per\ pound) = \left(\frac{35.34+2.68+2.8+2}{522}\right) + \left(\frac{2.5625}{522}\right) + (0.01) = \$0.102 = 10.2 \text{ cents per pound of beef}$$

Source: Mus (2006)

After the various role-players were divided into their categories and the costs were summarised Mus (2006) calculated the total farm-to-fork cost for a pound of beef, and the result was that a full chain traceability system in the USA would cost 10.2 cents for each pound of beef.

Another research study on the costs and benefits for the US voluntary traceability system was conducted by Blasi *et al.* (2009). In Table 2.15 below, one can see what the influence of the adoption of the NAIS system has on maintaining the access to export markets. If the export demands for beef from the USA were to be increased by 23 %, this would pay for a 70 % adoption rate of the full animal identification and traceability system over a period of 10 years. With this scenario, the other possible benefits from traceability systems are not taken into account.

*Table 2.15: Net annual gain in beef producer surplus under varying adoption of full ID and Tracing rates.*

| *Full Tracing Adoption Rate* | *Export Market Loss Avoided* | | | |
|---|---|---|---|---|
| | 0 % | 10 % | 25 % | 50 % |
| | ($/head sold) | | | |
| *30%* | **-$3.72** | $3.59 | $14.53 | $32.74 |
| *50%* | -$5.62 | **$1.70** | $12.63 | $30.85 |
| *70%* | -$8.99 | -$1.68 | **$9.26** | $27.47 |
| *90%* | -$15.02 | -$7.71 | $3.23 | **$21.45** |

Source: Blasi *et al*. (2009)

Blasi *et al.* (2009) also considered the domestic demand of beef and realised that with an adoption rate of 30 %, there was a possibility that the domestic demand may increase by 0.24 %, while an adoption of 90 % might increase domestic demand by 0.96 %. The conclusion therefore was that the overall total net benefits for the adoption of the NAIS system were positive.

## 2.13 Conclusion

Throughout the literature, it can be seen clearly that food safety has become a very important issue. Food-borne illnesses cause many hospitalisations each year, and there are about 5000 related deaths each year in the United States of America. According to statistics of the USDA, companies recalled 18 675 102 pounds of meat in 2014. In South Africa, Tiger Brands had to recall Tastic products which contained traces of unsafe colorants (USDA, 2015; Mead *et al*., 1999; ENCA, 2015). In this regard, a traceability system is very important.

The livestock industry, of which the beef industry is part, accounts for 40 % of the global gross value of agricultural production. This is an indication that the beef and livestock industry plays an important role in the global food supply, as well as in the global economy (FAO, 2003).

The beef industry plays a very important role in the South African economy, as well as in food security. According to Spies (2011), South Africa does have the potential to become a leading producer of beef in Southern Africa. As part of Spies' (2011) study, he interviewed 143 commercial producers who stated that 60 % of their income came from livestock farming. According to DAFF, the gross value of all the beef produced during the period from 2003/4 until 2012/13 was R11.3 billion.

South Africa's current grading system is a good system, but it is mainly aimed at the producer. There are countries like Australia which have better systems. Strydom (2011) is of opinion that if we want to improve the current classification system, we should adopt the Meat Standards Australia (MSA) system, which considers more factors when grading and classifying the meat, than the current system we are using does. For an MSA system like this to be implemented, the country should have a good traceability system in place.

Traceability can be defined as the ability to access any or all information relating to the product which is under consideration, throughout its entire life cycle, by means of recorded identification (Olsen and Borit, 2013). This will add value to the product, by enhancing the information relating to the product, for the consumer.

Regattieri *et al* (2007) introduced a traceability framework which divides traceability into four main parts, namely product identification, data to trace, product routing, and traceability tools. Zhang and Bhatt (2014) divided traceability into two main concepts according to HACCP. These two concepts are Critical Tracking Events and Key Data Elements. This is only a simpler model than the model introduced by Regattieri *et al* (2007). This concept should be usable, to facilitate the implementation of such a system for beef in South Africa.

Throughout the literature, it is clear that traceability is extremely important and Trevarthen (2006) stated that one could find a worldwide trend towards improving traceability systems because of the increasing occurrences of disease incidents such as mad cow disease. Hobbs (2006) stated that consumers' demands for traceability increase as the amount of food scare incidents increase. He also found that the demand for differentiated food products is increasing and that there is an increase in innovation for better quality measurements, as well as for tracking and information management technologies. All these drivers have pushed traceability to the forefront, and this is also applicable to the beef industry in South Africa.

It is clear in the literature that most of the bigger beef producing countries and economic union have mandatory traceability systems. The European Union, which is the biggest importer beef products, introduced traceability in 1997. The New Zealand traceability system, known as the New Zealand NLIS system, became mandatory in 2011. Other countries which have compulsory systems are Ireland, Brazil, Namibia, Canada, Argentina and Uruguay, to only name a few (Schroeder and Tonsor, 2012).

There are many studies in the literature where the results were clear that consumers do demand traceability of food products. The biggest proof can be found in Buhr (2003) where he reported as follows: "Consumers demand to know where their food came from and how it was produced". He believed that traceability is the tool that can be used to protect certain brand attributes, which is important in the modern world where brands are becoming more important.

# Chapter 3 Methodology

## 3.1 Global Overview

The first step in this research was to establish the specific requirements of the important existing traceability standards and requirements, globally. The reason for that is to ensure that the proposed framework does comply with all these standards. The second step was to establish the important characteristics of the systems of the bigger importing and exporting countries. These countries and economic union include European states, Japan, South Korea, Namibia, Botswana, the United States of America, Brazil, China, Australia, Argentina, Canada, New Zealand, Mexico and Uruguay. The characteristics that were focused on are the depth, breadth and precision of the systems (Golan et al., 2004). Other important variables that might influence these characteristics of a traceability system, and which should be taken into consideration, are whether the system is mandatory or voluntary, which parts of the supply chain are covered, the reasons for adoption, and the type of data that is captured in the system (Sarig, 2003; Schroeder and Tonsor, 2012; Pendell and Belk, 2003; Charlebois *et al*., 2012; Souza-Monteiro and Caswell, 2004). The global standards that were studied and used in the establishment of the framework are ISO 22005:2007, GS1 Traceability standards, the European Food Law, the World Organisation of Animal Health's Territorial Health Code, The World Trade Organisation's General Agreements on Tariffs, the FAO's guidelines for safety and quality in the meat industry, the Codex Alimentarius, and International Committee for Animal Recording (ICAR) standards.

## 3.2 South African Laws and Regulations

Certain South African Laws and regulations should be taken into account, as South African role-players should still comply with them. These laws and regulations include the following:

- The Animal Identification Act, 6 of 2002

- Stock Theft Act, 57 of 1956
- The Meat Safety Act, 40 of 2002
- Agricultural Product Standards Act, 119 of 1990
- Red Meat Regulations R1072
- Foodstuffs, Cosmetics and Disinfectants Act, 54 of 1972 (Regulation R908)
- Consumers Protection Act, 68 of 2008

Accordingly, it is important to ensure that the requirements of these Acts are part of the voluntary beef traceability framework.

## 3.3 Conceptual Frameworks

Karlsen *et al*. (2013) established that there is no common theoretical framework that is used for the implementation of a voluntary traceability system, globally. Various authors have established certain frameworks, but none of these frameworks considers the entire value chain, or the laws and regulations unique to South Africa.

Some of the conceptual frameworks found in literature are the Critical Tracking Event (CTE) and Key Data Element (KDE) model (Zhang and Bhatt, 2014; Welt and Blanchfield, 2012; Miller and Welt, 2014), The Food Track and Trace Ontology (FTTO) model (Badia-Melis *et al.,* 2015; Pizzuti *et al*., 2014), and the TraceFood framework (Storøy *et al*., 2003, and Tracefood.org.). For the purpose of this study, the CTE and KDE model is used, together with the generic framework established by Zhang and Bhatt (2014), to build a framework, for each of the role-players in the beef value chain, for a voluntary beef traceability system.

The definitions that is used for Critical Tracking Events (CTEs) is the following: “A CTE is any occurrence involving an item at a specific location and time associated with collection and storage of data useful for associating the item (or related items) to the specific occurrence at a later time and is determined to be necessary for identifying the actual path of an item through the supply chain” (Welt and Blanchfield, 2012).

The key data elements can be defined as those data points that will be captured at each of the above-mentioned CTEs to ensure that, in the case of a recall or for quality control, one can identify where the problem occurred.

## 3.4 Value chain for beef

The value chain that we use to establish the correct CTEs and KDEs is the one of Will (2004) and Roduner (2005) who explain the domestic and export value chains and role-players for beef. Therefore, the CTE and KDE model is used establish a framework for each of these role-players.

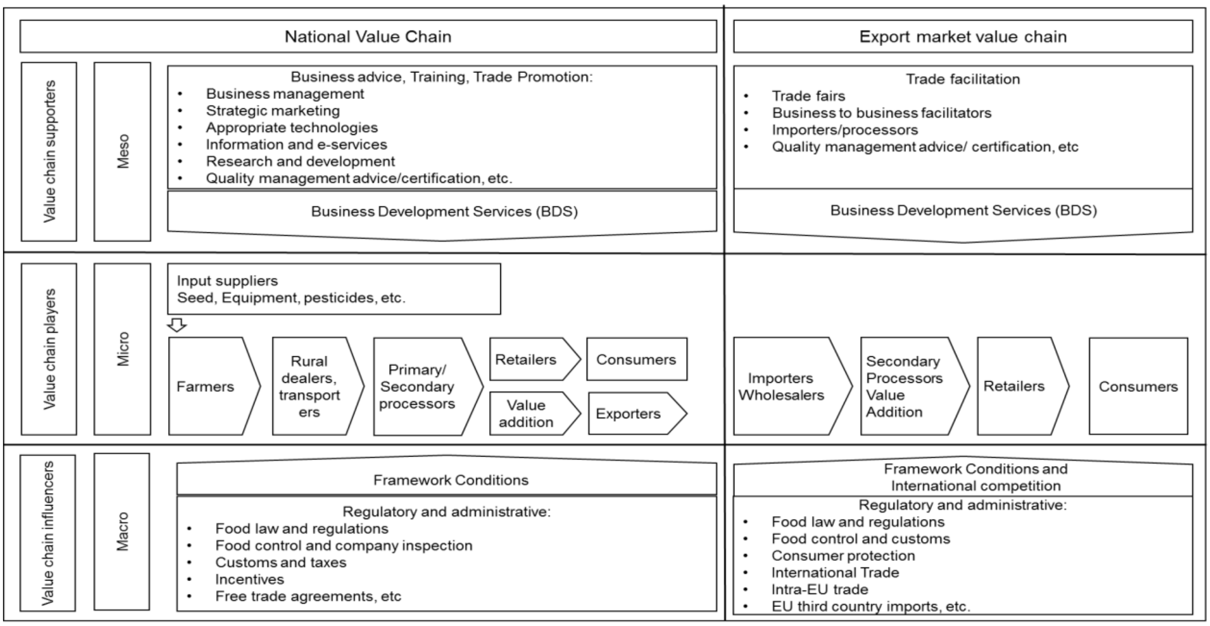



*Figure 3.1: Beef value chain*

Source: Will (2004) and Roduner (2005)

The agricultural marketing channel (Figure 3.2 below), as explained by Rhodes, Dauve and Parcell (2007), is used with the value chain, as seen in Figure 3.1 above. This ensures that the correct information on the product and quality of the product flows from the primary value chain to the next role-player in the value chain, up to the end consumer, while more information on consumer preferences and money can flow from the end consumer back to the primary producer. This ensures that consumers' preferences can be met.

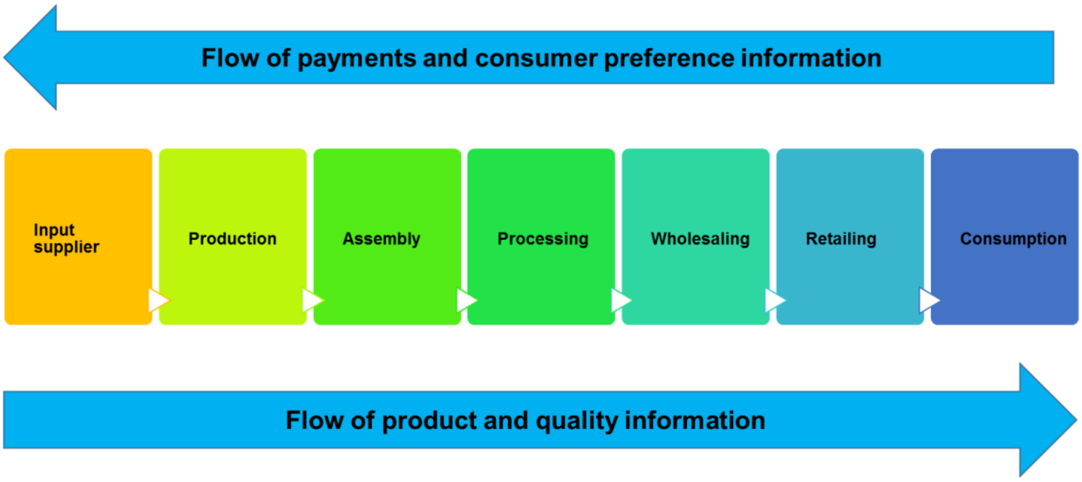



*Figure 3.2: Agricultural Marketing Channel*

Source: Rhodes, Dauve and Parcell (2007)

# Chapter 4 - Article 1: Beef Traceability- An overview of the current status

Running title: Overview of beef traceability.

**Beef traceability – an overview of the current status**

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## Abstract

Food safety has become an important factor and the importance of beef traceability cannot be ignored. Most of the big importing and exporting countries and economic unions have introduced traceability requirements and these systems are summarised in this review. Included are the European Union, Japan, South Korea, Argentina, Namibia, Uruguay, Botswana, United States of America, South Africa and China. Non-profit organisations who focus on the livestock industry, as well as those who focus on establishing standards, have well-known traceability standards, which are listed. These standards are adopted by private companies to stay competitive in the global market. Additionally, conceptual frameworks in traceability, specifically the three more well-known frameworks (CTE and KDE framework, Food Track and Trace Ontology and the TraceFood framework) are discussed. Using the three characteristics of traceability, namely depth, breadth and precision, these existing systems are divided into three levels, with level 1 the most basic and level 3 an advanced system. The status of traceability in South Africa in relation to other beef producing and beef importing countries and economic unions, as well as the effect thereof on the domestic beef industry, is discussed.

## 4.1 Introduction

World food safety has increasingly become an important factor in the beef industry. According to Sarig (2003), approximately seven million people were affected in the early 2000s by food-borne illness. The outbreak of Bovine Spongiform Encephalopathy in Europe was one of the main reasons consumers lost confidence in beef products in the United Kingdom between 1984 and 1987 (Souza-Monteiro and Caswell, 2004). These events can be seen as the main motivation for countries to introduce traceability as a tool to protect human health.

There are various definitions of food traceability. Webster's Dictionary (University of Florida, 2009) defines traceability as "the ability to follow or study in detail, or step by step, the history of a certain activity or a process" (Sarig, 2003). The ISO 8402 (1994) definition is supported by the EU Parliament of 2002 where the product can be followed through all stages of production and distribution. Traceability should incorporate an identification system whereby information on the product at any stage of the supply chain can be accessed (OECD, 2003; Olsen and Borit, 2013). The identification system should be upheld by the different operators involved in the supply chain so that there is a link between the animal and the product (Regulation EC 1760/2000). The identification of a product and the ability to trace it through records in order to know more about the product are the two implicit elements found in these definitions.

Traceability is implemented to achieve certain objectives and has various characteristics and methods of analysis. According to Germain (2005), traceability provides a tool to achieve three main objectives, namely managing risks related to food safety and animal health issues, guarantee products' authenticity to provide customers with reliable information, and lastly to improve product quality and processes. Golan *et al*. (2004) states that a traceability system has three main characteristics. The first characteristic is the breadth, which is defined as the amount of information a traceability system records. The more information a system records, the more breadth a system has. The second characteristic, the depth of the system, is determined by how far back and forward the system can track information on a product. The third characteristic is the precision of a system. The precision reflects the degree of assurance with which a system can pinpoint a particular food product movement or characteristic. This is determined by the unit of analysis used in the system and an acceptable error rate. Regattieri *et al*. (2007) identified four pillars of traceability. These four pillars are product identification, data to trace, product routing and traceability tools. Souza-Monteiro and Caswell (2004) identified four patterns for adoption of traceability systems in the major producing and trading countries and economic unions. The first pattern is the adoption of a mandatory traceability system in response to consumer concern. One economic union and one country that followed this pattern are the European Union and Japan. The second pattern was followed by Australia, Brazil and Argentina. With this pattern, a mandatory traceability system is adopted to maintain or enhance export market share. Canada follows the third pattern where industry manages mandatory programmes for animal identification. The fourth pattern is a voluntary traceability system as used by the United States of America (USA). Although most of the countries prefer mandatory traceability systems, the United States differs in this respect and prefers a voluntary system. Some argue this might let them lag behind other beef producing countries (Murphy, Pendell and Smith, 2009; Smith *et al.,* 2008).

Traditional trade barriers, such as tariffs, have been replaced by food safety regulations and standards. These developments, with an emphasis on health requirements, influence the export of food products by developing countries and play a role in market access (Frohberg, Grote and Winter, 2006). Traceability, as well animal identification legislation and requirements, should not be seen as an obstacle for developing countries, but rather as an opportunity to gain market access with a healthier product and a competitive advantage in export markets (Pavon, 2014). Traceability can also assist companies in brand building (Buhr, 2003). A reliable and permanent animal identification system is one of the main goals for the implementation of a traceability system, as traceability is not possible if proper animal identification does not exist (Carné, Gipson, Rovai, Merkel and Caja, 2009). A traceability system also benefits producers and breeders who can improve herd management and selection based on certain criteria.

An understandable traceability framework, based on international best practices, is needed in developing countries. This will give a clear guideline for each role-player in the red meat value chain to implement a voluntary, internationally acceptable traceability system. This article reviews the current status of global traceability adoption and what levels of adoption can be found according to three characteristics of traceability. The objectives are to determine:

- Global standards for food traceability, with an emphasis on beef.
- Traceability systems and level of use in big importing and exporting countries and economic unions.
- Current conceptual frameworks.

## 4.2 Methodology

The search engine Google Scholar was used to find relevant articles. The specific search phrases ‘traceability systems in beef producing countries’, ‘beef traceability regulations’, ‘benefits of beef traceability systems’, ‘importance of beef traceability systems’, ‘existing beef traceability frameworks and global traceability standards’, were used.

Other resources included the Global Food Traceability Center’s website and the resources that were available there. The websites of the big standard organisations, namely the International Standards Organization, as well as Global Standards 1 and the European Food Law, were accessed. Organisations with influence in the beef industry on a global level, such as the International Committee of animal recording, were also used to ensure that a clear understanding of the current situation of global traceability was achieved.

## 4.3 Current global traceability standards – legal and regulatory requirements

There are numerous global traceability standards, each governed by their own set of requirements. The big standards organisations all introduced traceability standards in recent years. For example, Global Standards 1 with their Global Traceability Standard, as well as the well-known International Standards Organization with ISO 22005 of 2007, which focuses only on traceability. The Codex Alimentarius is also a well-respected standard, which puts emphasis on traceability. Other well-known world organisations who focus on food safety and agricultural production introduced traceability into their standards and best practices. These organisations include the World Organization of Animal Health (OIE), World Trade organization (WTO), Food and Agricultural Organization of the United Nations (FAO) and lastly the International Committee for Animal Recording (ICAR). The European Union also introduced traceability regulations, which cannot be ignored by any country or company which are considering exporting beef to a country in the European Union. The main standards are listed below.

### 4.3.1 GS1

The GS1 is an organisation that provides a common language to assist companies to identify, capture and share important information relevant to their industry in a way that other customers, suppliers and partners can understand. One of these standards is the GS1 Global Traceability Standard:

> "This GS1 Global Traceability standard will maximize the usage of the well-established, globally acceptable and voluntary GS1 supply chain standards that uniquely identify a traceable item, describe the establishment of appropriate and effective records of events, and provides for accurate communication about the traceable item between trading partners." (GS1, 2012).

The basis of this standard is that companies should be able to use the "one step backward and one step forward" traceability principle. In other words, the company should be able to give all information on where the inputs of a certain product came from and where the product was dispatched after production. Additionally, the GS1 introduced the Traceable Item Matrix (see Figure 4.1 below), which provides the requirements for the logistical hierarchy levels as well as the precision of the identification. Precision of the identification includes a generic identification indicating basic precision and a unique identification indicating the most precision achieved.

In Figure 4.1, the global trade item number (GTIN) is the GS1 identification key of a trade item. This key comprises a company prefix followed by a reference number for the product and a check digit. The batch/lot number can either refer to the trade item itself or to items contained within the trade item. All information considered to be relevant for traceability purposes are associated with the trade number, which forms part of the batch/lot number. The shipment identification number (SIN) is the reference number of a specific shipment, and contains all the information about that shipment. A serial shipping container code (SSCC) is the identification key that the GS1 uses to identify a logistical unit. This key comprises an extension digit, serial reference, check digit and a GS1 Company prefix. The serialised global trade item number (SGTIN) is used to identify items at retail, case and carton levels. There is a GS1-assigned company prefix and item reference, combined with a serial number. Traditionally, GS1 barcodes were used, but the SGTIN specification combined with an electronic product code (EPC) tag gives visibility beyond the item reference, right down to the exact serial number. An EPC tag contains a unique identification number, which is important for traceability purposes. This tag stores information of the item, which can later be retrieved from the database and thus ensures reliable traceability.

### 4.3.2 ISO 22005: 2007.

This standard is named “Traceability in the feed and food chain- General principles and basic requirements for system design and implementation.” The standard sets out the general requirements and principles for the design and implementation of a traceability system for either feed or food (Bourquin, 2015).

Under ISO 22005:2007, a company should at least know who the immediate supplier of inputs and who the immediate customers are. The basic traceability principle of one-up and one-down applies. Food safety is the joint responsibility of all the actors in the supply chain and one weak link can result in unsafe food, which presents health hazards to consumers as well as financial loss to suppliers. Food and feed businesses should determine food safety, quality and other objectives, after which they design a system that meets all regulatory requirements. The system should include the identification of a product as well as a database or computerised system where the records are kept. The system should be implemented and training be given. It is also important that the system be monitored, reviewed and updated. These all form part of the requirements of this standard (Bell, Homer and Kissinger-Matray, 2015).

ISO cannot certify a company, but the organisation develops certain standards and has standards for the certification process. Certification is issued by a third party who acts as the certification body. For example, two certification bodies in South Africa include the African Accreditation Cooperation (AFRAC) and the Southern African Development Community Cooperation in Accreditation (SADCA).

### 4.3.3 European Union (EU)

In 2000, the European Union introduced regulations on traceability, Regulation (EC) 1760/2000. The regulation has two main objectives. The first is to establish an efficient system of identification and registration for bovines at the production stage, which starts on farm with the birth of the animal. The second is to define a common European labelling scheme in the beef sector, based on objective criteria at the marketing level of the food chain.

In objective one, the requirements for animal identification and registration are clear. Two individual ear tags are used. An animal passport accompanies the animal or carcass wherever it goes. Each member state of the European Union needs to establish its own computerised database to establish the link between the farm and abattoir. It is important that the records be kept for a limited time of three years. The data in the database will be verified by designated national authorities.

In objective two, there are two labelling schemes, the “compulsory community beef labelling system” and the “voluntary labelling system”. In the compulsory system, all carcasses or batches of carcasses should include a reference number. Other compulsory information on the label includes the registration number of the abattoir, the country of origin, and locations where any other processing of the carcasses took place. It is mandatory for this identification system to at least record information on the arrivals and departures of livestock and carcasses, as well as meat cuts, between operators to guarantee correlations (Souza-Monteiro and Caswell, 2004).
Article 18 of the General Food Law Regulation (EC) 178/2002, applicable to business operators, stipulates that all food, feed and food-producing animals, as well as feed suppliers, should be able to establish a traceability system through the entire beef value chain. They should also be able to identify all their suppliers who provided input and the data should be made available if requested. Further, it is also a requirement that businesses should be able to identify other businesses to which they supplied their product and the make the information available. All food and feed products should

be labelled in the correct manner and relevant documentation be available (Germain, 2005).

### 4.3.4 World Organisation of Animal Health (OIE).

This is an intergovernmental organisation of animal health, of which 175 member countries and territories are part. The Territorial Health Code is the document where the principles for animal identification and traceability are published in order to promote disease prevention and control. The procedures recommended by the OIE are the following:

- Provide for unique animal or group lot identification.
- Provide for animal traceability.
- Establish birth time period.
- Determine when an animal was introduced into an establishment,
- Include arrangements for retiring identification device. (Codex Alimentarius, 2015; European Food Law, 2002).

All data, as well as any changes, should be reported to a central authority. Certification should be provided to prevent disease transmission. Schroeder and Tonsor (2012) state that traceability is a tool for controlling animal disease and ensuring food safety, because traceability links food through the intermediate steps to its origin.

The OIE determined the general principles for animal identification and animal traceability at an ad hoc committee meeting in 2005. The key principles include animal identification, animal traceability, zoning/compartmentalisation, competent authority managing a specific country's system, and lastly the management of zoonosis through traceability. The OIE also lists education and training as an important aspect surrounding traceability.

### 4.3.5 World Trade Organization (WTO)

The General Agreements on Tariffs and Trade (GATT) was introduced in 1995 and accordingly the WTO supports governments who impose sanitary and phytosanitary measures (SPS) to protect human, animal or plant life or health. According to the SPS, these countries can make recommendations so that their trade policies employ international standards, guidelines and recommendations to ensure protection.
The WTO SPS has important components to take note of:

- Traceability can be implemented as an SPS measure by a country.
- This country should meet the following obligations:
- The measures should be scientifically justified and should be based on a risk assessment;
- These measures should be appropriate under certain circumstances;
- The measures should never be more restrictive than what is required,
- And should be applied consistently across countries.

If the exporting and importing country have measures that ensure similar levels of health protection, then the importing country should accept those measures (Schroeder and Tonsor, 2012; Wilson and Beers, 2001).

Another measure, the Technical Barriers in Trade (TBT), was adopted by the WTO in an attempt to prevent the misuse of non- tariff barriers. "TBT measures comprise technical standards, along with regulations on test and inspection procedures and certifications. They are developed by organizations such as the International Standard Organization (ISO)" (Frohberg, Grote and Winter, 2006). Developing countries struggle to participate in international trade, because of the TBT and SPS agreements of the WTO. Only some countries like Mexico, Thailand, South Africa, Argentina, Malaysia, Brazil and Chile regularly participate in certain activities (Henson and Jaffee, 2007).

### 4.3.6 Food and Agricultural Organization of the United Nations (FAO)

In 2004, the FAO published good practices for the meat industry. This guide contains details on animal identification and traceability mechanisms. The documentation of traceability is a standard that has quickly become the norm in animal health management and consumer assurance. Therefore, the aim of the FAO guide is to provide guidelines to the meat industry in the implementation of raising quality and safety standards (Schroeder and Tonsor, 2012).

### 4.3.7 Codex Alimentarius

This code states the importance of animal identification and that the carcass can be traced from the abattoir to the place of origin. The main aim of this code is to develop hygiene provisions for meat. This starts at the farm of origin, then throughout the value chain, up to the retail industry. According to this code, regulatory investigation should be possible where necessary. The code is known as the Codex Code of Hygienic Practice for Meat (Code) (Schroeder and Tonsor, 2012).

"Within established Codex texts, traceability as it relates to the distribution and location of the product after delivery has been expressed partially in the General Principles of Food Hygiene and the General Standard for the Labelling of Pre-packaged Foods, with references to Lot Identification and the ability to recall product if necessary. At the moment, Codex texts do not require manufacturers or distributors to maintain records of onward distribution, with the exception of the Code of Practice for Low-Acid and Acidified Low-Acid Canned Food." (Barcos *et al*., 2005).

### 4.3.8 International Committee for Animal Recording (ICAR standards)

The ICAR adopted the two recognised standards for Radio Frequency Identification (RFID) technology used for animal identification. These two standards are ISO 11784 and ISO 11785. Both full duplex as well as half duplex transponders are accommodated by these standards. Conformance and performance standards in relation to devices containing these two ISO compliant transponders have been developed and are administered by the ICAR (Britt *et al.,* 2013).

## 4.4 Traceability Systems and Level of Use in Various Countries

Table 4.1 below summarises the biggest importing and exporting countries and economic union of beef products, as well as some of the traceability systems they employ. The main motivations for most countries and economic union to introduce traceability are to engender consumer confidence and to control disease in domestic herds. Some countries implemented traceability to protect their market access, because their export markets require a traceability function. The biggest importing markets are more focused on consumer confidence and food safety, while the exporters are more concerned with herd health and market access. The European Union, Japan and South Korea are definitely the leaders in beef traceability. The USA lags behind its competitors in the beef industry with regard to the development of a traceability system (Smith *et al.,* 2008; Smith *et al.,* 2005). The US Federal Government supports a voluntary traceability system, rather than a mandatory traceability system. This could be one of the reasons why the USA has lost its competitive advantage in some of the markets (Murphy, Pendell and Smith, 2009). Brazil also has a national voluntary traceability system; however, for export producers, the system is compulsory as traceability ensures access to export markets.

Olsen and Borit (2012) outlined seven driving forces for the implementation of traceability, which include labour and cost reduction, enhancing the chain of communication, giving a company a competitive advantage, documentation of sustainability, legislation, food safety, and lastly certification. The USA employs a voluntary farm-to-retail traceability system for branded products like organic and hormone-free products. Japan and the EU already have a birth-to-retail traceability system in place, while China intends to adopt a birth-to-retail traceability system. The other countries, as seen in Table 4.1 below, only have mandatory birth-to-slaughter traceability systems.

The Food Law of the People's Republic of China (PRC), which provides national food safety laws and regulations, was established by the Chinese Government. In 2009, this law was promulgated and from there on, food producers had to establish purchase inspection records. All matters related to this law have to be recorded and this includes notes on all purchases and sales (Liu *et al.,* 2012). This system has a similar structure to that of the GFTC framework, which recognises the input and output of the product, as well as the movement of the product (Zhang and Bhatt, 2014).

There are also differences that can be found in the types of data countries decide to capture in their traceability systems. This influences the breadth of a traceability system and in Table 4.2 below, one can see how the traceability systems differ in terms of the three characteristics of traceability (breadth, depth, and precision). The countries' and EU systems also differ in terms of the three characteristics of traceability (breadth, depth and precision) as seen in Table 4.2; the same countries and the EU are used in Table 4.1 and Table 4.2. South Korea's systems are the most advanced, according to the breadth, depth and precision. They already have farm-to-retail as well as retail-to-farm systems in place, which gives them the best depth of all the systems. The possibility exists that they might upgrade to have a system in place where they can track from feed to retail. Australia, Canada and New Zealand also have good depth in their traceability systems, but not as good as the European Union, Japan and South Korea. The other countries discussed in this article only have a basic depth, which is internationally required (Table 4.2 below). Except for the EU, Japan and South Korea, most of the other countries have the same breadth, namely farm-to-slaughter traceability. This being said, Australia and New Zealand could increase the breadth of their traceability systems by introducing retail-to-farm traceability in the near future. With the "The Food Law of PRC", China is working towards introducing a full value chain traceability system in the near future to enhance food safety.

Most of the countries have good precision through being able to trace the animal back to its place of birth, although the verification systems used by these countries also differ. Most of the countries, like Uruguay, Botswana, Namibia, as with other developing countries, still use livestock inspectors to verify information. Australia, South Korea, the EU and Japan have started using DNA or retinal analysis. The cost of these verification methods are, however, expensive and this makes it difficult for developing countries to adopt.

Given the information in Tables 4.1 and 4.2 below, the countries used in this review can be divided into three groups, based on the level at which they adopt traceability (Table 4.3 below). Level 1 is the basic adoption of traceability with basic, depth breadth and precision. Level 1 includes tracing groups of animals to their place of birth, information regarding safety and origin is captured, and basic farm-to-abattoir traceability is adopted.

Level 2 includes tracing individual animals to their place of origin, and limited information regarding animal welfare, safety and feed is captured. This level has more depth than level 1, with a farm-to-retail traceability system, but not a complete feed producer-to-retail traceability system. There is an abattoir-to-export traceability in level 2.

The level 3 contains all information regarding safety, origin, animal welfare, feed and other information, thus having the most breadth in the system. The precision of this system is exact, with countries able to track individual animals, and consumers having access to information regarding individual animals.

Countries with a level 3 traceability system include the EU, Japan and South Korea. Countries who adopt a level 2 traceability system include Australia, Canada and New Zealand, while the other countries are categorised as level 1. China currently has a level 1 traceability system, but is planning to upgrade to a mandatory level 3 system. These levels can be used by countries that plan on adopting a traceability system to evaluate what is needed to adopt the required level of traceability for their purposes. Level 1 is a good starting point and creates an opportunity for the system to evolve through implementation and increasing role player experience, to the next level.

## 4.5 Conceptual traceability frameworks

There is no common theoretical framework with respect to the implementation of food traceability (Karlsen *et al.,* 2013). Three of the most well-known conceptual frameworks of traceability will be discussed and include the Critical Tracking Event and Key Data element framework, the Food Track and Trace Ontology Framework, and lastly the TraceFood Framework.

### 4.5.1 Critical Tracking Events and Key Data Elements Framework

One element of critical tracking events (CTE) is the touch point for traceability where data are collected or shared as a product/animal is moved (Bhatt, 2015). Another element is the key data elements (KDE) where the pieces of data are related to the three pillars of traceability (Bhatt, 2015).

Critical tracking events can be divided into four main categories in the supply chain (Miller and Welt, 2014):

- Terminal CTEs: these events exist at the terminals of a supply chain (for example, cooling, washing and sorting).
- Aggregation/Disaggregation CTEs: these events precede terminal CTEs (for example, packaging).
- Transfer CTEs: this is when any movement of the product in the supply chain occurs (for example, loading on the truck and shipping).
- Commingling CTEs: these CTEs occur when a new product is formed and when various products from different sources are combined.

Welt and Blanchfield (2012) named several advantages of CTEs. These advantages include:

- Immediate universal participation is not a requirement to benefit from the use of CTEs.
- While maintaining ownership and control of the CTE data, operators are free to choose the methods and technologies according to their requirements and availability.

Zhang and Bhatt (2014) established a generic CTE-KDE Framework (Figure 4.2 below) which can be used in the establishment of a traceability system. This framework consists of the important CTEs, creation, transportation, transformation and depletion. Additionally, the important KDEs (who, what, when, where) are established and links what needs to be captured at each of the CTEs. This could be used to identify what, and when, data should be captured in the value chain.

### 4.5.2 Food Track and Trace Ontology (FTTO) model

"Ontology is an explicit formal specification of terms in the domain and relations among them, supports the management of a unique body of knowledge through the integration of different concepts and terms coming from heterogeneous sources of information and uses involved in the supply chain" (Badia-Melis, Mishra and Ruiz-Garcia, 2015).

Four main classes consist in the FTTO ontology and are described by Pizzuti *et al*. (2014) as:

- Agent: an agent is an entity or actor involved in the process of food manipulation.
- Food product: this class includes ingredients such as salt, spices, sugar, oil and vinegar in food products, in the form of raw material or manipulated products.
- Service products: these are the products used during manipulation of raw materials or during the transformation phase, such as phytosanitary products, colouring and flavouring and food additives. It also includes materials of packaging and container of products.
- Process: business processes and agro-food processes are included in this class.

### 4.5.3 TraceFood framework

There are three generic principles of traceability, namely unique identification units, documentation of transformation and standardisation for information exchange. The TraceFood framework is based on these three principles and uses them to provide guidelines on how to implement an electronic chain of traceability. The TraceFood framework consists of six components (Figure 4.3 below):

- Principle of unique identification – The first main requirement of the TraceFood Framework is Unique Identification of Traceable Units and Logistic Units. The second requirement is that a minimum amount of information on a Traceable Unit should be collected throughout its lifetime. The GS1 Standards and the

GS1 numbering system are used in the unique identification of Trade Units (TUs) as well as Logistic Units (LUs).

- Documentation of transformation of units – It is important to keep track of all splitting or transformations of a TU to be able to track and trace the product when necessary. Various steps were established to ensure that a specific TU can be tracked or traced, starting firstly with defining the TU for the specific business under examination. Secondly, the unique identification of the TU should be recorded and in cases where no unique identification exists, one should be allocated. It is also important that all the identifications of TUs dispatched should be recorded.

- Generic language for electronic exchange of information – Two types of messages exist in any electronic information interchange of a product, namely a request for data and a response to that request. In the TraceFood framework, the TraceCore eXtensible Markup language was developed in an attempt to establish a standard way for data exchange.

- Sector-specific language for electronic information exchange – Clear and unambiguous information interchange is very important in any sector. Each sector should specify how certain properties should be measured, as well as what they should be called. That is why it is important to have sector-specific standards for properties and values, which form part of a specific sector.

- Generic guidelines for implementation of traceability – A parameter list is included in the generic guidelines for the implementation of traceability. The data that should be recorded, as stated in the parameter list, includes producer and TU identification.

- Sector-specific guidelines for implementation of traceability – It is important that each sector should develop sector-specific guidelines for the adoption of traceability. It is also important that these guidelines are product specific and include a standardised parameter list throughout the entire value chain of a product. Additionally, the specific data that should be recorded at each link in the value chain and should be identified. Lastly, it is important to establish information exchange and data management for both chain traceability and internal traceability.

## 4.6 Implications of a Traceability System and the South African Context

Olsen and Borit (2012) outlined several driving forces for the implementation of traceability. These include labour and cost reduction, chain communication enhancement, competitive advantage gained by companies, and documentation of sustainability. Problems may arise when there is an inability to link food chain records that characterise the current traceability system, or records are inaccurate, or there are delays in obtaining essential data. The access to this information is key in case of a food-related disease outbreak and is necessary for the job of food safety agents (Pizzuti *et al.,* 2014).

Developed countries adopt high levels of traceability, while developing countries have basic systems in place. Unfortunately, some well-known developing countries, such as South Africa, have no traceability system in place. Traceability can no longer be ignored by developing countries, as the adoption thereof can be crucial in securing export markets, which in turn could help economic growth and job creation.

South Africa exports to various countries throughout the world (SARS, 2015). During January 2013 to October 2015, beef exports to the Isle of Man comprised 20 916 518 kg (R 885 961 659.00 in total= R42.36/kg), Hong Kong 4 982 488 kg (R21 083 627.00 in total = R43.92/kg), Italy 2 765 601 kg (R100 246 071 in total = R 36.25/kg), Jordan 4 841 325 kg (R270 306 315.00 in total = R55.83/kg), and Kuwait 6 437 651 kg (R 419 243 872.00 in total = R65.12/kg)(41). Future revenue from these countries may be compromised if no traceability system is in place in South Africa.

## 4.7 Conclusion

Traceability is an important requirement in the food industry and countries who do not implement a traceability system will be left out of the global meat market. There are different conceptual frameworks that can be used to establish a national traceability system, with the CTE and KDE framework being the latest development, which is the easiest one to use and the most accurate. There are also various standards which give one an accurate idea of what is required. Countries who still need to adopt a traceability system can decide which level they require, and use the CTE and KDE framework to establish the desired level of adoption. Therefore, it is possible to use a voluntary beef traceability system to expand the exporting opportunities. There is a need for such a framework which considers all the standards discussed in this article, as well as systems used in various countries. This could help South Africa become more competitive in the beef market.

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## 4.9 Figure legends

Figure 4.1: Traceable Item Matrix (see below)
(Source: GS1, 2012)

Figure 4.2: Generic Framework (see below)
(Source: Modified from Zhang and Bhatt (40)).

Figure 4.3: Components of the TraceFood Framework (see below)
(Source: Modified from Storøy et al.(33)).

*Table 4.1: Traceability Systems in Big Exporting and Importing Countries*

| Country | Date introduced | Standard code | System name | Mandatory/ Voluntary | Which parts of the supply chain | Reasons for adoption of traceability | Animal data captured in the system | | | | | | Consumers access to information | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | National individual identification | Trace to range origin | Movement tracking | Age Verification | Diet verification | Health records | | |
| USA | May 2002 | COOL Have no traceability system name | Farm security and Rural Investment Act of 2002 | Voluntary | Farm to retail for branded products like Non- Hormone Beef | Disease control | Voluntary | Voluntary | Voluntary | Voluntary | Voluntary | Voluntary | | 1 |
| Brazil | 2002 | ERAS, SISBOV, GTA | Brazilian system of Identification and Certification of Origin for Bovine and Buffalo | Voluntary | Birth to slaughter | Disease control, market access | Yes | Yes | Yes | Yes | Yes | Yes | | 1, |
| Australia | 1999 | | National Livestock Identification System (NLIS) | Mandatory | Birth to slaughter | Food safety, disease control, market access | Yes | Yes | Yes | Tag issue date | Yes undue LPA | Yes undue LPA | | 1, |
| | | | Cattle Tracking System (CTS) | | | | | | | | | | | 6 |
| New Zealand | Launch 2006 and mandatory form 2011 | NAIT | National Animal Identification and Tracing | Mandatory | Farm to slaughter | Disease control, market access | Yes | Yes | Yes | Yes | Voluntary | Voluntary | | 6 |
| | Implementation 2011 | | National livestock Database (NLDB) | | | | | | | | | | | 4, |
| China | | | | Will be mandatory in the near future | Birth to retail | | | | | | | | | 4, |
| Namibia | | | Farm assured Meat Scheme (FANMS) | Mandatory | Birth to slaughter | Market access and disease control | Yes | Yes | Yes | Yes | Voluntary | Yes | | 3, |
| Botswana | 2001 | | Livestock Identification and Trace-back System (LITS) | Mandatory | Birth to slaughter | Maintain access to export market | Yes | Yes | Yes | Yes | Voluntary | Yes | | 3, |
| Canada | 2002 | | Canadian Cattle Identification Agency (CCIA) | Mandatory | Birth to slaughter | Market access, disease control | Yes | Yes | Yes | Voluntary | No | No | | 2, |
| Argentina | 2007 | | Argentina Animal Health Information System – Sistema de Gestion Sanitaria (SGS) | Mandatory | | Disease control, market access | Yes | Yes | Yes | Yes | No | Yes FMD vaccination | | 1, |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Uruguay | 2006 | | Division de Contralor de Semovientes (DICOSE) and National Livestock information System (SNIG) | Mandatory | Farm to slaughter | Disease control, market access | Yes | Yes | Yes | Yes | Some | Some | | 4 |
| Japan | 2003 | | Cattle Traceability law | Mandatory | Birth to retail | Enhance consumers' confidence | Yes | Yes | Yes | Yes | No | No | date and place of birth, sex, breed, production history | 4, |
| Mexico | 2003 | | National Livestock Individual Animal Identification System (SINIGA) | Mandatory | Birth to slaughter | Disease control, census | Yes | Yes | Yes | Yes | No | No | | 2, |
| South Korea | 2004 | Reviewed 2009 | South Korea beef traceability system | Mandatory | Birth to retail | Food safety, disease control | Yes | Yes | Yes | Yes | No | No | date and of birth, sex, breed, production history | 2, |
| European Union | 2003 | | | Mandatory | Birth to retail | Disease control, Consumers confidence | Yes | Yes | Yes | Yes | No | No | | 2, |

(*28*) Sarig (2003), (*29*) Schroeder and Tonsor (2012), (*25*) Pendell and Belk. 2008 *R*eview: Identification and Traceability of Cattle in Selected Countries Outside of North America (*30 or 31*) Smith et al. 2008 post slaughter traceability, (*29*) Schroeder and Tonsor (2012) International cattle ID and traceability: Competitive implications for the US. http://www.mla.com.au/Meat-safety-and-traceability/National-Livestock-Identification-System online access march 2016 (*9*) Charlebois et al. (2014) Comparison of Global Food Traceability Regulations and requirements.http://foodsafety.govt.nz/elibrary/industry/Improving_Traceability-Role_Nzfsa.htm online accessed in March 2016 (*18*) Souza-Monteiro and Caswell The Economics of Implementing Traceability in Beef Supply Chains: Trends in Major Producing and Trading Countries 2004

*Table 4.2: Countries' Systems According to the Three Characteristics of Traceability*

| | Depth | | | | | | Breath | | Precision | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Feed producers to retail | Retail to farm | Farm to abattoir | Abattoir to retail | Abattoir to exports | Abattoir to import ports | Safety and origin | Safety origin, animal welfare, feed and others | Individual animals to their place of birth | Groups of animals to place of birth |
| | P | X | X | X | | | X | P | X | X |
| | P | X | X | X | | | X | | X | |
| | | P | X | | | X | X | P | X | |
| | | | X | | | | | X | | X |
| n | | | X | | X | | X | | | X |
| | | | X | | X | | X | | | X |
| ates of | | | P | P | | | P | | P | |
| | | | X | | X | | X | | | X |
| a | | | X | | X | | X | | X | |
| rea | P | X | X | X | | | X | | X | |
| and | P | P | X | | | | | X | X | |
| | | | X | | X | | X | | X | |
| | | | X | | | | X | | X | |
| | | P | P | P | | P | | P | P | |

X identifies the current breadth, depth and precision the country has in place while P is possible improvements to the system in near future.

(Source: Modified from Souza-Monteiro and Caswell (*32*)).

*Table 4.3: Countries divided into three possible traceability adoption levels according to characteristics*

| Country | Level 1 | Level2 | Level 3 |
|---|---|---|---|
| EU | | | X |
| Japan | | | X |
| Australia | | X | |
| Brazil | X | | |
| Argentina | X | | |
| Canada | | X | |
| United States of America | X | | |
| Namibia | X | | |
| Botswana | X | | |
| South Korea | | | X |
| New Zealand | | X | |
| Mexico | X | | |
| Uruguay | X | | |
| China | X | | |

Source: Own illustration

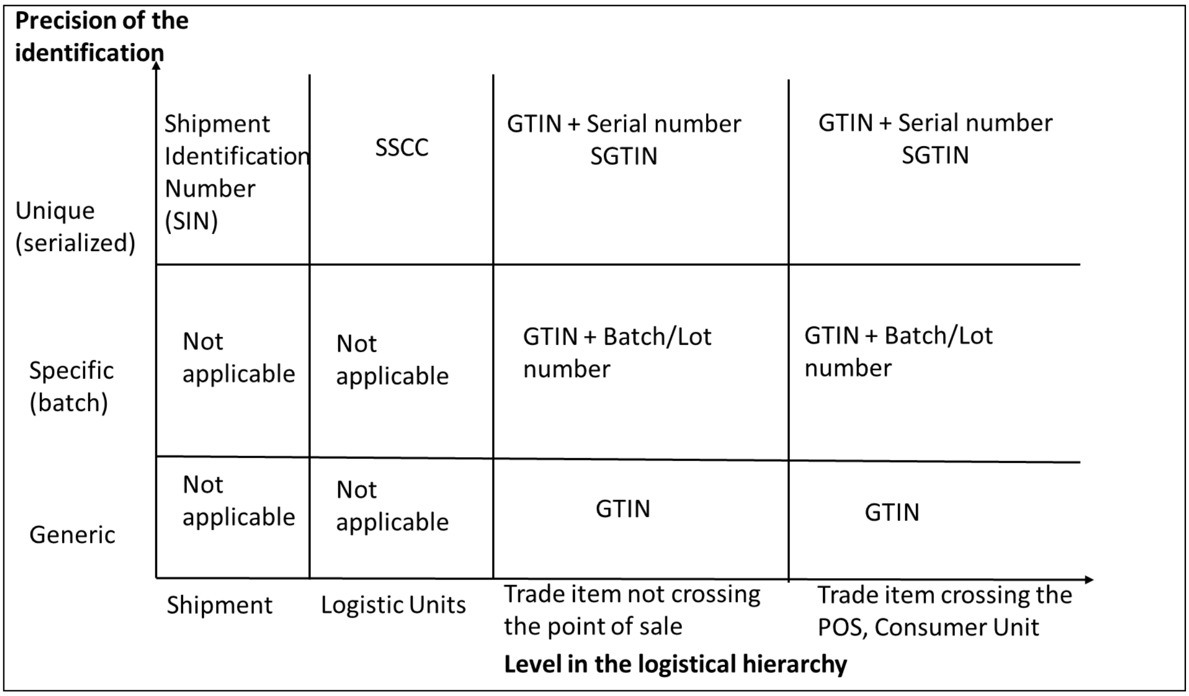


*Figure 4.1: Traceable Item Matrix*

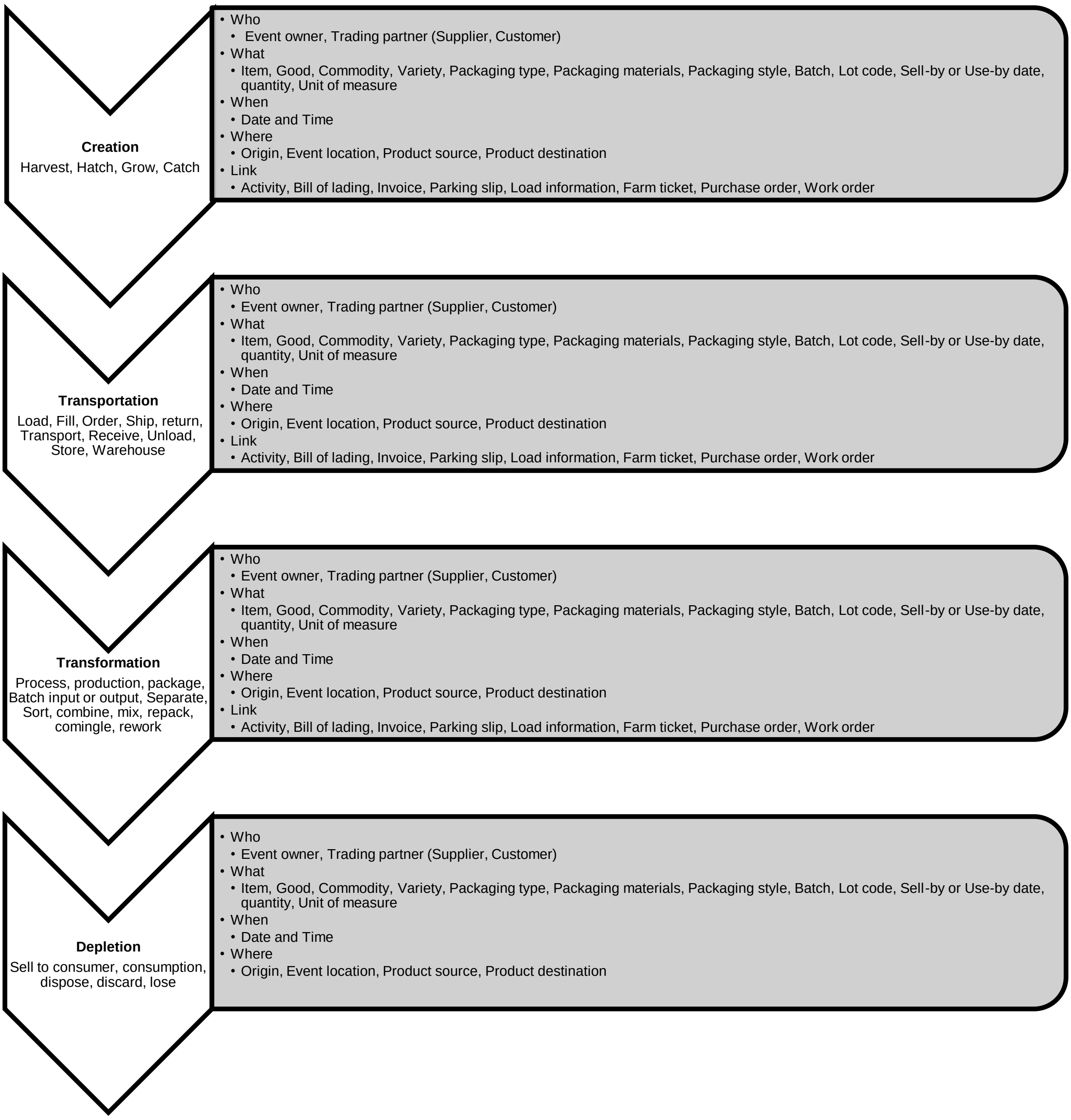


*Figure 4.2: Generic Framework*

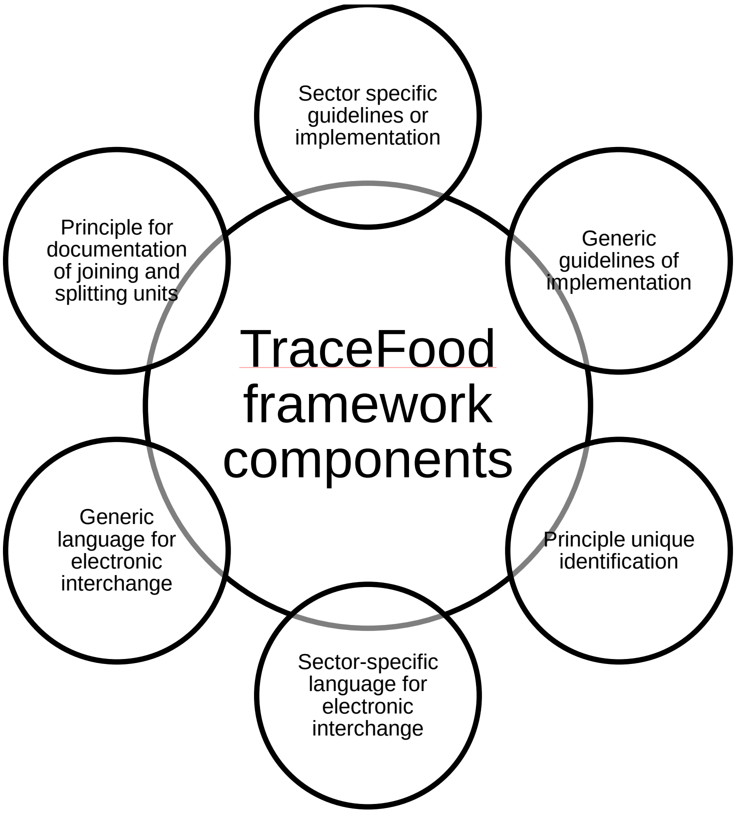


*Figure 4.3: Components of the TraceFood framework*

# Chapter 5 - Article 2: Framework for voluntary pre-slaughter beef traceability system

By PA Calitz and BJ Willemse

## Abstract

This article is a second in a series of three articles by Calitz and Willemse where they compiled a framework from farm to consumer for beef that can be adopted voluntarily by role-players in the industry. For the purpose of this article, the framework from farm to pre-slaughter as well as the benefits of traceability for each of these role-players. The framework discussed in this article took South African laws and regulations into account, as the main aim is that this framework could be used by role-players in the beef industry to voluntarily adopt traceability. This framework also complies with global standards and can compete with systems in other beef producing countries.

**Key words: South Africa, Voluntary, Beef Traceability**

## 5.1 Introduction

As consumers lose confidence in the safety of food, and as food scarcity increases, countries as well as businesses demand greater traceability Therefore, it is important for countries to accept these requirements and to adopt traceability. This article is the second in a series of articles by Calitz and Willemse (2016). The first has been submitted for publication and is an overview of the current status of traceability, in which an in-depth study was done of all the variables that play an important role in the establishment of a globally acceptable traceability system. This study includes a literature overview of systems in other beef-producing countries, global standards from the various well-known standardisation agencies, and conceptual frameworks established for traceability in recent years. The aim of this article is to take the information gathered in article 1 and establish an easily understandable framework from farm to pre-slaughter that can be adopted by any country or business on a voluntary basis while it still complies with global standards. Therefore, various important aspects of traceability will be discussed shortly, the first of which is the definition of traceability. There are various definitions for traceability, which was explained in a previous article submitted for publication by Calitz and Willemse (2016), but the one that explains traceability the best for the beef industry is the following: "Traceability is the ability to follow food, feed, food-producing animals or ingredients through all stages of production and distribution" (EU, 2000). Taking this definition into account, it is important to understand that traceability has three main characteristics, which are breadth, depth and precision (Golan et al., 2004). These characteristics were discussed in more depth in previous articles and can be used to derive mandatory, as well as voluntary, traceability systems into different levels, where level one will be a basic system and level two will be more advanced, while level three is the most advanced system. Various authors have discussed different benefits for the adoption of traceability (Trautman, Goddard and Nilsson, 2002; Fisher, 2015; Souza--Monteiro and Caswell, 2004; Mooketsi, 2013). Fisher (2015) divided the benefits of traceability into three main groups which can be sub-divided further. These three main groups are operational efficiency, market access and risk mitigation. Operational efficiency consists of improved supply chain management, increased supply chain confidence, process improvements and decreased spoilage, waste and shrinkage. Improved brand reputation, increased consumer confidence and new customers all form part of the market access benefits that traceability has. Risk mitigation benefits consist of insurance and liability cost reduction and reduced recall costs, as a business can recover faster after a recall, which influences profitability. The above-mentioned benefits are all motivations companies use to voluntarily adopt a traceability system. Trautman, Goddard and Nilsson (2002) did an in-depth overview of the benefits for the various role-players in the beef value chain.

Much research has been done on the current status of traceability in various beef producing countries and regions which was summarised in an article by Calitz and Willemse (2016). Various conceptual frameworks on traceability have been established and are discussed in depth in the literature (Badia-Melis, Mishra and Ruiz-Garcia, 2015; Zhang and Bhatt, 2015; Welt and Blanchfield, 2012; Pizzuti *et al*., 2014 and Tracefood.org.). One of these frameworks will be used to establish a framework from farm to pre-slaughter that can be adopted on a voluntary basis that will comply with international standards and will be of the same standard as other systems in other countries.

## 5.2 Traceability Systems in South Africa

Some research has been done on the South African Fruit industry, which is exporting approximately 80 % of its produce. As its biggest exporting markets are the European Union and the United States of America, it had to adopt traceability, as it is a requirement in those markets (Olivier, Fourie and Evans, 2006). More extensive research has been done on the traceability of Karoo lamb. The main aim of one of these research projects was to characterise the traceability systems currently being used in the abattoirs in South Africa. Traceability is an important tool used for Karoo Lamb to verify the origin of the lamb, which ensures that the lamb is originally from the Karoo, and the management practices are those typically used to ensure the Karoo lamb quality and attributes (Kirsten, Jordaan and Van der Merwe, 2013).

The South African ostrich industry has had to adopt traceability, as it is required by its export markets. The export market plays a very important role in the profitability of the industry. The ostrich industry is a good example of where traceability was adopted to gain access to export markets and for disease control purposes, and the system is successful (Ostrich Business Chamber, 2016; Kleinkaroomeat, 2016).

## 5.3 Methodology

Various conceptual frameworks can be found in literature for food traceability. There is no common theoretical framework for the implementation of traceability in the food industry (Karlsen *et al*., 2013). Some of the conceptual frameworks found in literature are the Critical Tracking Event (CTE) and Key Data Element (KDE) models (Zhang and Bhatt, 2014: Welt and Blanchfield, 2012: Miller and Welt, 2014), The Food Track and Trace Ontology (FTTO) model (Badia-Melis *et al*., 2015; Pizzuti *et al*., 2014), and the TraceFood framework (Storøy *et al*., 2003; Tracefood.org.).

For this purpose of this study, the CTE and KDE model will be used, together with the generic framework established by Zhang and Bhatt (2014), to build a framework for each of the role-players in the beef value chain, up to the abattoir, for a voluntary traceability system. Global standards, such as GS1, ISO 22000:2005 and ICAR standards, will also be taken into consideration to ensure that the framework complies with these standards. The establishing of Critical Tracking Events and Key Data

Elements for the three levels of traceability will be done separately, as each level comes with different benefits and aims.

Figure 5.1 below illustrates the value chain used to identify the various role-players in the beef industry, for the domestic as well as the export market. For the purpose of this article, the traceability frameworks will only be established for the Farmer, Auction and Feedlot, taking all the information gathered in the article by Calitz and Willemse (2016) into consideration to ensure that the framework is of the same standard as those of the other beef-producing countries in the world.

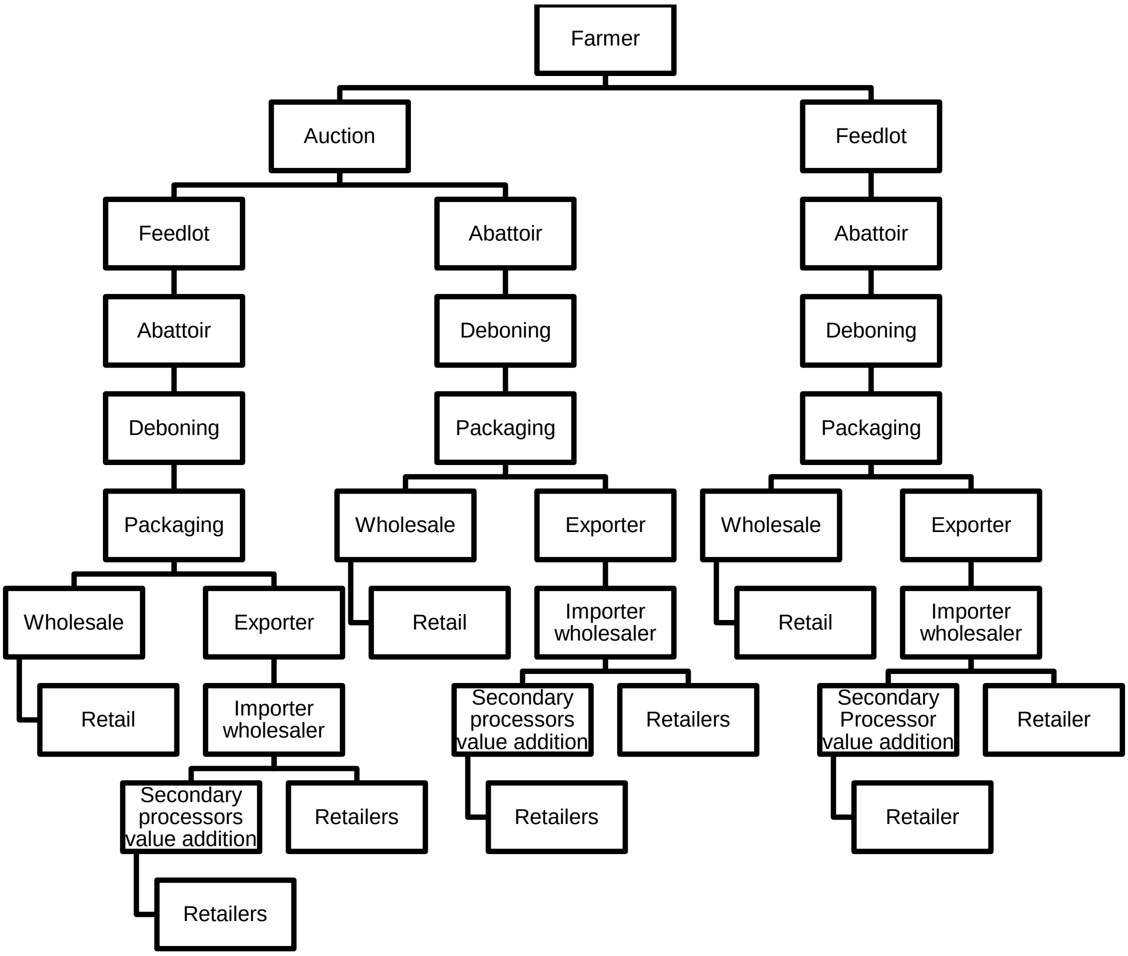


*Figure 5.1 Domestic and Exporting Beef Value Chain*

Source: Own illustration

## 5.4 On-farm traceability

Most of the global traceability systems assessed in the literature start at farm level and stop being mandatory at slaughter (Smith *et al*., 2008; Sarig, 2003; Schroeder and Tonsor, 2012; Souza-Monteiro and Caswell, 2004). Very few of the systems of the major beef-producing countries continue being mandatory after slaughter, except for Japan and South Korea, where farm-to-retail traceability is mandatory.

One thing that is clear, is that on-farm traceability is extremely important, especially if the motivation for the adoption of traceability is to achieve better herd health and to control stock theft, amongst other things. It is also important to understand that without identification of the animal or product, or if any link in the supply chain is missing, the traceability system will fail. It also plays an important role in certain products with specific attributes like organic and grass-fed beef, which are becoming more popular. The farm is the place where the production of a product starts, and thus where traceability needs to start. Traceability can only be applied when an animal is identified and you can only start tracing the animal from the point of identification. The more complete a system is at this part of the value chain, the more complete the system for the end product will be, although the capturing of data tends to be the most difficult at this point.

One of the biggest problems currently experienced in South Africa is that there is a group of farmers that do not have a sufficient recordkeeping system. In South Africa, it is compulsory to use branding on cattle older than six months, and calves and small stock should be tattooed in the ear with a farmer's registered mark or initials. Unfortunately, this is not enough for a traceability system, as it does not give any data on the individual animal. According to the Animal Identification Act (2006), farmers are required to mark their small stock with a tattooed branding mark from the age of one month old, and cattle should also be marked with a tattooed branding mark up to the age of six months, after which it should be marked permanently with a hot or freezer branding iron. Thus because of this law, farmers are supposed to work with their young livestock within a month after birth. The big question is what the requirements will be for farmers who adopt a voluntary traceability system, and what information will be required. If CTEs and KDEs are used to establish a framework, the birth, health, feeding, movement and disposal data will all be Critical Tracking Events, while each of these events will have its own data that is important for the different levels of traceability adoption, as seen in Figure 5.2 below. The birth of the animal must be registered within a month after birth, and the animal must be tagged with a unique identification.

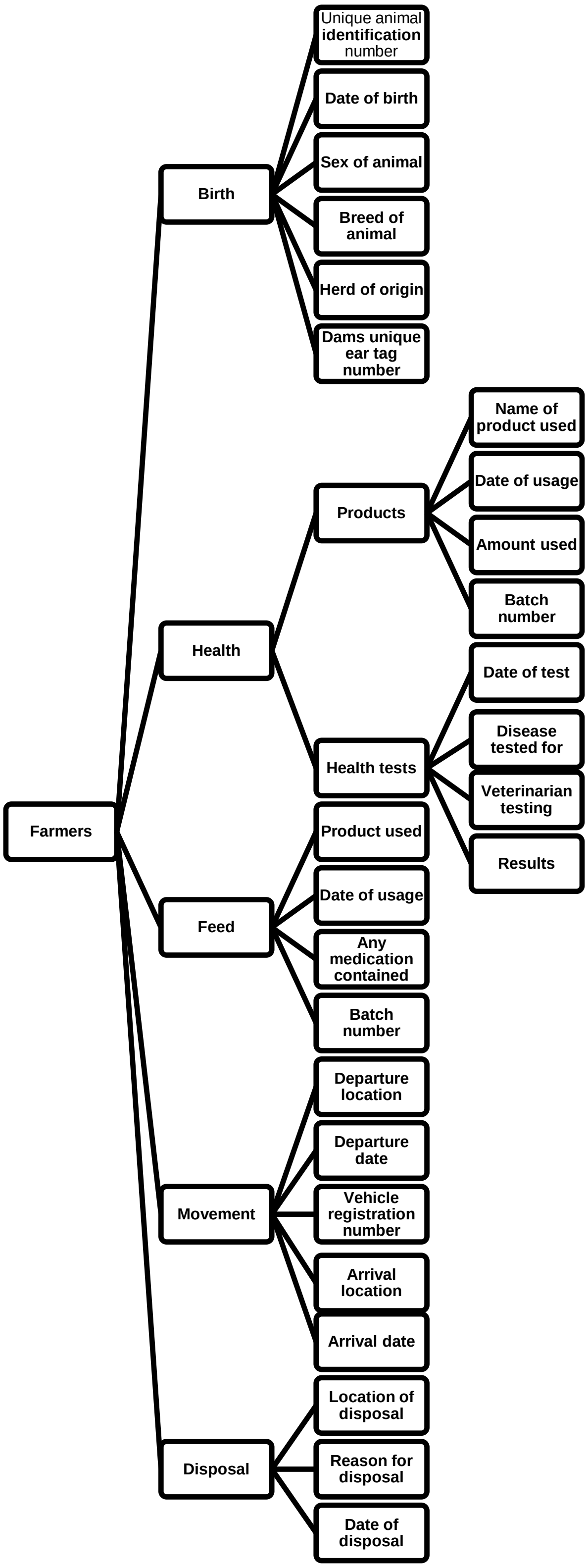


*Figure 5.2: Traceability Framework for on-farm Traceability*
Source: Own Illustration

### 5.4.1 Birth as Critical Tracking Event

The first Critical Tracking Event for an animal will be at the point of birth, or at least within three months after birth, for cattle. There are certain data points that should be collected. The data that will be compulsory for level 1 traceability will be the month of birth and year of birth. These two points form part of the date of birth in figure 1. The animal's unique identification code will be compulsory, no matter which level of traceability applies to an individual animal. The third KDE will be the sex of the animal. The fourth compulsory KDE will be the herd of origin. In other words from which farm and breeder does it come. This can be the registered herd number, or the geographical GPS coordinates, or the identification of a farm on a map. However, given the fact that the law requires farmers to have a registered mark, the easiest way will be to use the registered animal identification marks of farmers registered with government, and to focus on the owner.

The breed of the animal is another KDE that can be captured during this stage of the system. For level 1 traceability, one can only indicate if it is cross-bred or pure-bred, and if a cross-bred was used, whether dairy cattle was used. For level 2 and level 3 of traceability, one should indicate the breed of the animal and where cross-bred plays a role, the various breeds used should be given as indication. This will give the feedlot more management data on the performance they might expect.

The Final KDE under this Critical Tracking Event will be the dams' unique identification number. Under extreme extensive circumstances, this might be difficult for farmers as they might struggle to 'mother up', especially with small stock like sheep. In Level 1 traceability, this will not be a requirement. An individual who is farming very intensively, or a stud breeder, will adopt level 2 or level 3 traceability level where this data will be compulsory.

### 5.4.2 Health as a Critical Tracking Event

There are two very important parts of animal health considered as being CTEs. The first comprise the products used on the animal, while the second entails all the health tests an animal should pass to ensure national herd health, as well as food safety. Both these parts can be divided further into the various KDEs. The first compulsory

KDE for health, based on product information, is that the names of all products used on the animals should be captured, as well as the amounts used. This is important because some animal products can leave traces, or are not acceptable for certain markets. For level 2 and level 3 traceability, two separate KDEs should be captured. The date of usage will be compulsory for level 2, while both the date of usage and the batch number are compulsory for level 3 traceability.

The second part of animal health considered as being a CTE comprise the prescribed health test animals must undergo to ensure that no diseases spread and for the management of a healthy herd. It is important to capture the dates on which a test was conducted, for which disease/diseases the animal was tested, who the veterinarian was who tested the animal, and lastly what the results of the test were. To identify a veterinarian, one can use the veterinarian's registration number. These facts will definitely be compulsory for all 3 levels of traceability, as these can influence the health of the national herd and the quality of meat products. The diseases of concern include foot-and-mouth disease, tuberculosis and brucellosis.

### 5.4.3 Feed as a Critical Tracking Event

The two KDEs that will be compulsory from level 1 traceability up to level 3 traceability will be the name of feed used and the identification of what medication was added, in cases of where this occurs. In cases where only veld was used for feed, the farmer can indicate that and which mineral supplements were given, and what brand and type were used. For level 2, one can indicate the dates on which one started to use a specific product, and on which dates one stopped using those products. For level 3 traceability, one can include batch numbers, where possible.

### 5.4.4 Movement as a Critical Tracking Event

Movement as a CTE remains the same throughout the value chain. The same Key Data Elements need to be captured every time a live animal is moved. These Key Data Elements are departure location, departure date, vehicle registration number, arrival location, and arrival date. With the new law on the movement certificates that one should possess when moving an animal, this is already being done, although this data should only be captured, registered and shared where needed.

### 5.4.5 Disposal as a Critical Tracking Event

It happens from time to time that an animal does not complete the entire value chain and exits before it reaches the consumer. Some of the reasons might be death from natural causes or where the farmer slaughters it for own consumption. An animal might be stolen and its whereabouts might be unknown. In all these events, the farmer will capture the data surrounding the disposal. The farmer will capture the location of disposal. If the animal died on the farm, then the farm's identification code will be used, and if the animal was stolen or lost, the same will happen. The second KDE will be the reason for the disposal. In cases where the animal was sick, the illness should be stated, and in cases where the animal was stolen, this should be indicated. The date of disposal should also be captured, or in cases where it is not possible to capture the exact date, one should capture at least a timeframe within which disposal took place.

### 5.4.6 Benefits for the adoption of traceability on farm

Various authors describe these benefits as follows:

- Enhance animal health and better control of diseases.
- The economic impact of disease outbreaks can be reduced, as the sick animals can be identified sooner, which can reduce the spreading of certain diseases such as brucellosis, tuberculosis, and foot-and-mouth disease (FMD).
- Traceability enhances the efficiency of animal testing and disease control, which reduces the costs associated with the testing of the animals.
- Traceability increases transparency in the supply chain.
- Traceability increases differentiation and could be a good tool to use for farmers who produce products with specific attributes, e.g. organic beef or grass-fed beef.
- Price premiums could be paid to farmers who have good traceability records.

(Trautman, Goddard and Nilsson, 2002).

- Farmers can get carcass feedback from the abattoir, which can be used to modify management practices and breeding selection. This could improve breeding selection to supply the type of animals which have the attributes that are demanded by the market.

- Traceability enhances the linking of individual animal's performance back to the dam and sire of that animal. Therefore, it helps the farmer to make the correct genetic matches and to improve the genetic quality of the herd.

- Lost and stolen animals can be found easier and linked to the rightful owner.

(NLIS website, 2016).

Traceability reduces the incentives for farmers to cheat about the age of an animal or about the medical records of an animal (Hobbs, Yeung and Kerr, 2007).

- Improve farmers' efficiency because farmers use their scarce resources only on the best animals, and will not own animals that do not perform (Fisher, 2015).

## 5.5 Traceability at auctions and field agents

Although auctions and rural dealers comprise a very small part of the traceability system, we cannot forget what a crucial role they play. Thus, it is very important for them to form part of a traceability system. This is mostly the first point at which an animal leaves the farm. This is also a good place to track stolen animals. The two main role-players in this case are the auction houses and the field agents. The type of data that needs to be captured is mainly the data surrounding the departure of the animal, and then the arrival of the animal. In the case of an auction, there will be the departure of the animal from the farm and the arrival at the auction house. The animal will then depart the auction house after being sold and arrive at its new destination of the new owner. This is important for capturing these movements between locations of an animal. The arrival is the first CTE that needs to be captured at the auction, while the departure are the second CTE that needs to be captured. This framework will be the same for all three levels of traceability.

### 5.5.1 Departure as a CTE on farm

It is important that a farmer should capture certain KDEs when an animal leaves the farm. It is compulsory under the current legislation in South Africa to be in the possession of a movement certificate when one is transporting an animal (Article 6 and Article 8 of the law on Stock Theft, Act 57 of 1959). It is important that the farmer should capture the departure location (GPS coordinates), the unique animal identification number, and the registration number of the vehicle in which the animals are transported. In cases where large groups of animals are moved, a group of unique identification numbers will form a batch.

### 5.5.2 Arrival as a CTE at Auction

At the point of arrival, it is also important for the receiver to capture the location of arrival (GPS coordinates), the unique animal identification numbers of the animals involved, the date of arrival, the herd of origin/owner, and the vehicle registration number.

Under the arrival CTE, it is important that the most important KDEs are captured, namely date of arrival, location of arrival (this can be the GPS coordinates of the auction), and herd/owner of origin. (This is important for tracking the ownership of the animal).

### 5.5.3 Departure as a CTE at Auction

At the departure at the auction, the KDEs to record are the same as in any other departure of a live animal. The KDEs that need to be captured are the date of departure, location of departure, vehicle registration number, unique animal identification number, and arrival location.

### 5.5.4 Benefits for auctions to introduce traceability

- Can give buyers more assurance that the animals they buy are healthy and not stolen.
- They can reduce risks and liability claims.

- Can provide buyers with more information on the animals they buy, especially on feedlots and abattoirs.
- Sellers have less opportunity to cheat about information on the animals.

(Trautman, Goddard and Nilsson, 2008).

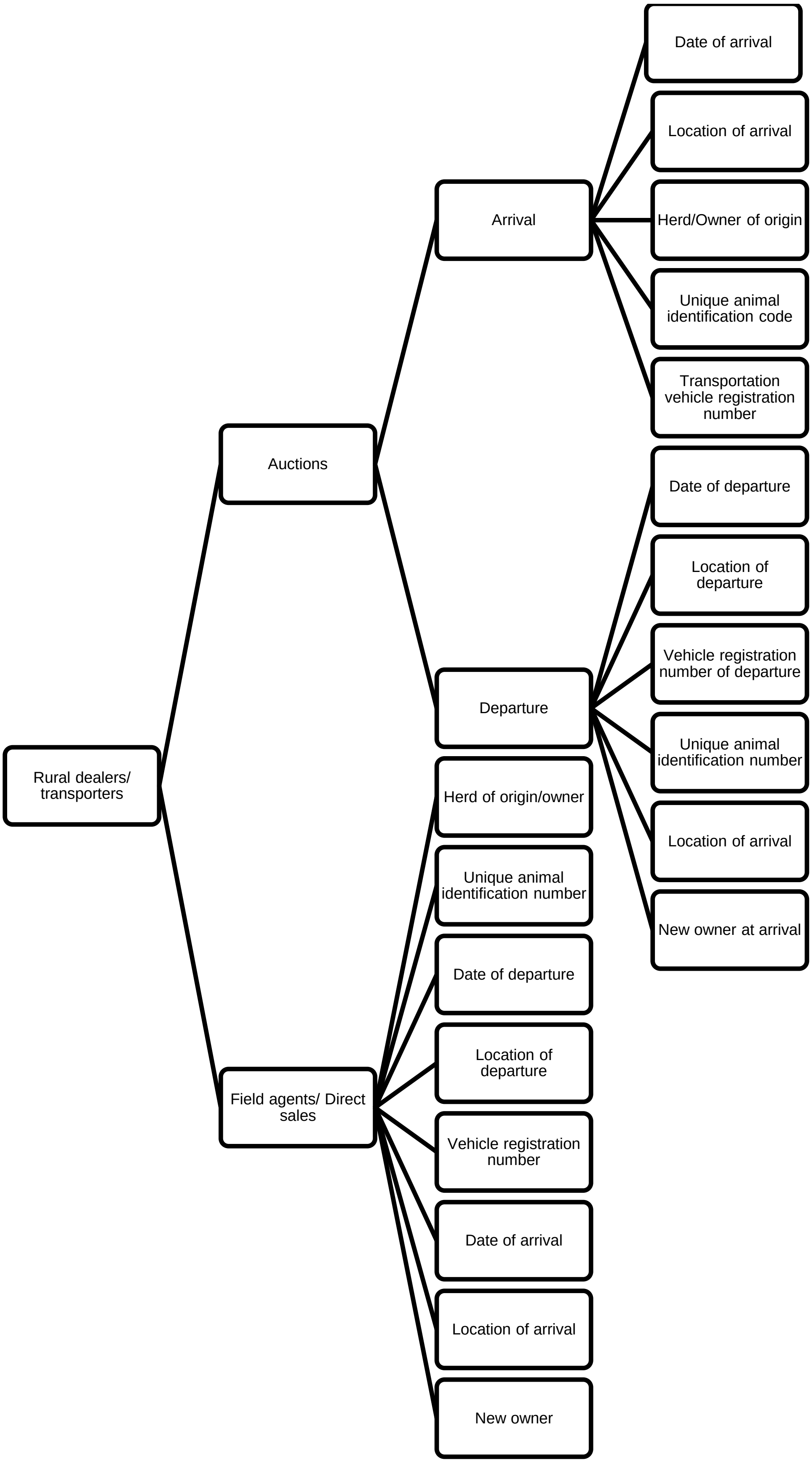


*Figure 5.3 Traceability Framework for traceability at auctions or sales agents*

Source: Own illustration

## 5.6 Traceability at feedlot

Around eighty per cent of all cattle in South Africa (2.2 million head of cattle) pass through a feedlot. Therefore, feedlots do play a very important part in the traceability system. The feedlot does not have as many CTEs as other role-players do, like the abattoir, but it does have some very important data. Some consumers do not prefer meat that contains any hormones, although it is legal to use hormones in South Africa to improve the growth of animals in the feedlot. Thus, it is of utmost importance to capture all data surrounding these inputs. The various CTEs that are important in a feedlot are: Arrival – whether it is from a farmer himself or from an auction; Health – this covers all the products used, as well as all tests conducted; Feed – it is important to capture all the feed used, or at least kind of feed used, and if it contained any medication; Disposal – this is only used as soon as an animal dies and is disposed of; and the last CTE is the Departure of the animal. These are important for keeping the chain of movement updated, for cases when a recall might take place.

### 5.6.1 Arrival as a CTE

On the arrival of an animal, it is important for the feedlot to capture the location from where it arrived, as well as who the primary producer (farmer) was. This could help the feedlot to build supply relationships with breeders whose animals perform in the feedlot, which contributes to the profits of the feedlot. This is also important for tracking the spread of certain diseases. The KDEs that need to be captured are the vehicle registration number, unique animal identification number, and date of arrival.

### 5.6.2 Feed as a CTE

It is important to identify the products used as feed in order to establish if they contained any products that might not be allowed by clients further down the value chain, for example antibiotics and GMO maize.

### 5.6.3 Health as a CTE

South Africa does have many problems with disease control, therefore it is important to test animals regularly and to keep records of all medical/veterinary products used on animals on the database. This will help to ensure that no trace or residue of products that have been used will end up in the meat of clients who prefer otherwise. Therefore, the Health CTE can be divided into two main KDEs, namely the products used and the health tests conducted. In the case of health tests, it is important to state for which disease a test was conducted, who the veterinarian was, the date of the test and the results of the test. In the case of products, it is important to state the name of the product, date of usage, amount used, and if any hormones were applied.

### 5.6.4 Disposal as a CTE

It happens that some animals die in the feedlot under various circumstances and need to be disposed of. In these cases, it is important to identify the date of disposal, where the animal was disposed of, and the reason for disposal. These are all very important measures that need to be taken to prevent the spread of diseases, as well as to take the animal out of the database.

### 5.6.5 Departure as a CTE

Departure takes place as soon as an animal moves from its current location. This is simply the movement order, and is the same as for all other cases where the animal departs. The KDEs that need to be captured are the date of departure, vehicle registration number, unique animal identification code, new location of arrival, and the date the animal arrived at its new location.

### 5.6.6 Benefits for feedlots to adopt traceability

- Traceability can ensure quality animals are bought that will perform in the feedlot.
- Traceability will help to ensure that all animals bought are healthy and that animals do not have any diseases that can be spread.
- Risk and liability can be reduced, as possible problems can be detected in time (Trautman, Goddard and Nilsson, 2008).

- Traceability can enhance efficiency and decrease waste in the feedlot (Fisher, 2015).

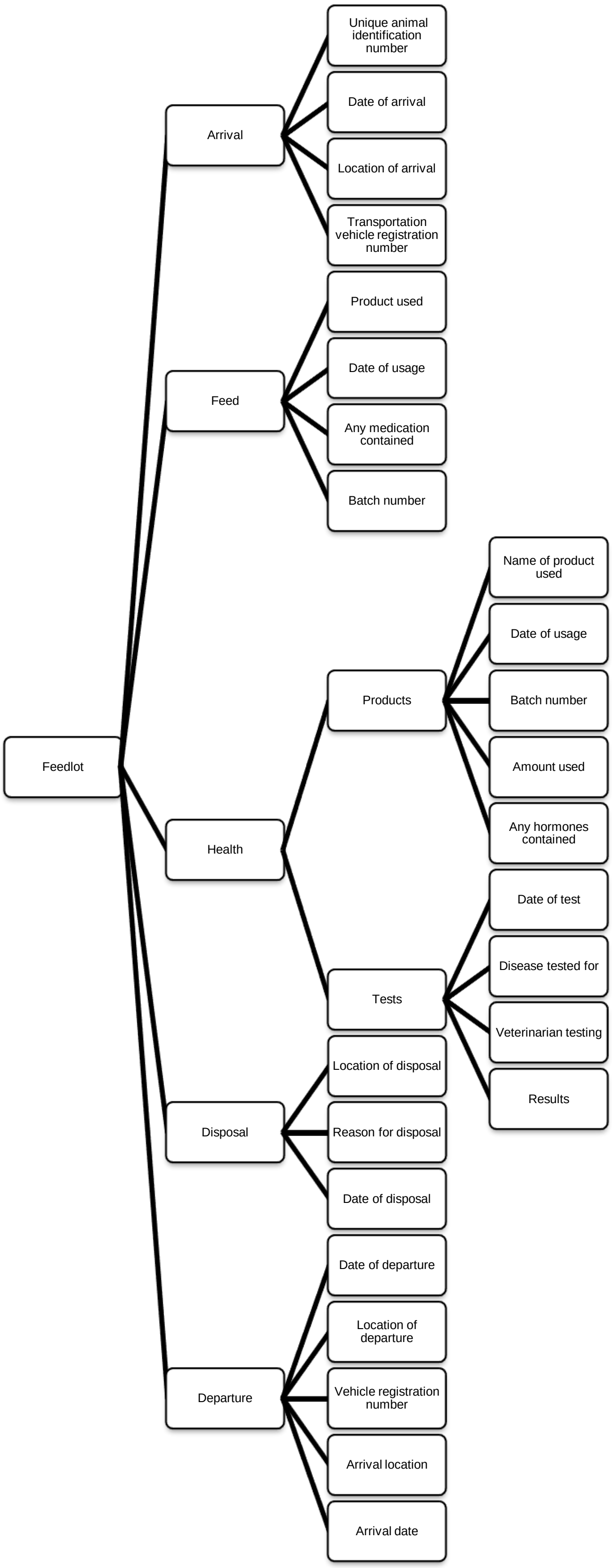


*Figure 5.4 Traceability Framework for traceability at the feedlot*

Source: Own illustration

## 5.7 Elements required when implementing a Livestock Identification and Traceability System (LITS) in practice

The following elements should also be given attention when implementing a LITS system, as identified by Britt (2013):

- An establishment registration system
- Animals or groups of animals should be physically identified
- Define movement documentation requirements
- A legal framework is required
- There should be a support programme to educate and train participants
- Proper audit measures should be put in place, with a query system.

## 5.8 The economics of a traceability adoption

There are various benefits for the adoption of traceability for each of the role-players in the industry. At the same time, there are various benefits for a country or industry as a whole. A report on the National Animal Identification System (NAIS) by the NAIS benefit-cost research team gives good financial indications on the industry benefits and importance of a traceability system. The United States of America, which has the NAIS system, does not have a mandatory system, although most of the producers adopt this system voluntarily. Therefore, the economic benefits show that it is possible for countries to maintain access to certain prestigious markets and still profit from them. According to the report by the NAIS benefit-cost research team, it is beneficial for the industry to adopt such systems as seen in Table 5.1 below.

*Table 5.1 Net annual gain in beef producer surplus under varying adoption of full ID and Tracing rates*

| Export market loss avoided | Full tracing adoption | | | | |
|---|---|---|---|---|---|
| | Percentage | 30 % | 50 % | 70 % | 90 % |
| 0 % | ($/Head sold) | -$3.72 | -$5.62 | -$8.99 | -$15.02 |
| 10 % | | $3.59 | $1.70 | -$1.68 | -$7.71 |
| 25 % | | $14.53 | $12.63 | $9.26 | $3.23 |
| 50 % | | $32.74 | $30.85 | $27.47 | $21.45 |

Source: Blasi *et al*. (2009)

In a 10-year period, it is possible to pay for a 70 % adoption rate in full animal identification and tracking, with a 23 % increase in beef exports by the United States of America. Therefore, there are definite economic advantages, and income to pay for the costs a company needs to cover, as traceability does come with certain costs.

One of the estimates of the NAIS report is that the current costs per operation range between $80 and $19 418 for operations ranging between 149 cows and 5000+ cows. The costs per cow were cheaper for bigger operations, at an estimate of $2.48, compared with those of smaller operations, at a cost of $5.12. Taking this costing into account, as well as the extra income from adopting traceability, it still is worth adopting such a system.

The traceability costs per operation in the feedlots also differed between operations with 1–999 head of cattle and big feedlots with 50000+ head of cattle. The small operations have an annual cost of $61, while the annual costs of the big operations are $36 216, which gives an average cost of $0.30 per head sold for the big operations, and $1.37 per head sold for small operations. Therefore, it is still worth the cost, if the extra profit could be $9.26 with an adoption rate of 70 %.

## 5.9 Conclusion

It is possible to use the CTE and KDE frameworks to establish an easily understandable and user-friendly framework for the South African beef industry. This framework would comply with international standards and give adopters the option of choosing which level of detail they want to adopt, as well as deciding what their aim is for adopting traceability. Level 1 traceability is the most basic level. The main aim for an adopter to decide to adopt level 1 traceability would be to enhance animal health, fight stock theft, and to ensure access to existing markets. On the other hand, a level two adopter would rather try to gain access to new, more prestigious markets (and export markets) as well as focusing more on herd quality. Level 3 traceability would be adopted by those who would like to gain access to premium markets, as well as those who focus on selecting and producing the best breeding stock and specific quality beef that is demanded by the market.

World-class traceability is becoming a prerequisite for those companies that want to gain access to certain domestic markets and export markets. A traceability system that complies with international requirements is also important for remaining competitive. It does not need to be compulsory in the country, but will be needed by companies to gain market access to certain markets. Animal breeders will have access to improved data that will advance selection and breeding for specific attributes required by specific markets, and this is becoming a requirement for exports markets. The implementation of the framework is easily understandable and is easy to adopt, and with technology, the implementation is made easier. Preliminary analysis of sheep feedlot data shows that the payback period of benefits/costs is relatively short and makes economic sense .This framework could be used by any company, in any country, to achieve these aims. Therefore, none of these role-players have any excuse not to adopt traceability on a voluntary level.

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# Chapter 6 - Article 3: Framework for voluntary post-slaughter beef traceability system

By PA Calitz and BJ Willemse


## Abstract

Two previous articles by Calitz and Willemse discussed the current global status of traceability and a possible farm to pre-slaughter traceability system, respectively. The aim of this article is to establish a post-slaughter traceability framework that can be voluntarily implemented. South Africa was kept in mind when the framework was researched, although the framework can be used by other countries and role-players as well. The CTE and KDE conceptual framework was used to establish an easily understandable framework for important role-players, such as abattoirs, deboning facilities, packaging plants, wholesalers, and retailers. The benefits for each of these role-players will be discussed shortly, followed by a short discussion on the economic implication of the implementation of a traceability system. In this research, it is clear that the implementation of a voluntary traceability system is definitely possible, as well as economically feasible, and is of utmost importance for the South African beef market.


## 6.1 Introduction

With food safety becoming increasingly more important, traceability is seen as a very important tool for ensuring safe food at all times, and in cases where contamination might occur. It would assist in recalling a product before it reaches the final consumer and thus improve food safety. This all forms part of an attempt to decrease the cases of food-borne illness which affects approximately seven million people per annum, globally (Sarig, 2003). Various definitions for traceability exist throughout literature which differ slightly from each other, and the best explanatory definition for the purpose of this article is the one in ISO 8402 which defines traceability as the ability to trace and follow food, feed, food-producing animals or ingredients, through all stages of production and distribution (ISO 8402:1994). This definition is supported by the EU Parliament of 2002.

The three basic objectives for the implementation of traceability are to manage risks related to food safety, to improve product quality and manufacturing processes, and lastly, to guarantee product authenticity (Germain, 2005). These are also the reasons why most of the surveyed countries have implemented traceability systems. Most of the important beef producing countries and regions, such as the United States of America, the European Union, Japan, Brazil, Australia, New Zealand, Botswana and Namibia, have introduced traceability systems (Sarig, 2003; Schroeder and Tonsor, 2012; Bowling *et al.*, 2008; Smith *et al*., 2008; Charlebois *et al*., 2014; Souza-Monteiro and Caswell, 2004).

The breadth, depth and precision of the systems of these countries and regions differ, where Japan and the European Union have more depth and breadth, as well as precision, because in these nations it is possible to track an animal from birth to the end consumer. Furthermore, these countries have a traceability system that operates throughout the entire value chain, and not only from farm to slaughter, as with most of the other countries (Souza-Monteiro and Caswell, 2004). With traceability becoming more important, most of the standardisation companies have established certain global traceability standards and guidelines which assist companies and countries with the implementation of traceability (ISO 22005:2007 ICAR, GS1 and EC 1760:2000 of European Parliament).

In 2014, Zhang and Bhatt compiled a guidance document for the adoption of traceability in seven sectors, of which the beef and poultry sector was one. They used the Critical Tracking Event (CTE) and Key Data Elements (KDE) conceptual framework to indicate important data that should be recorded for traceability purposes at important events in a product's lifecycle. Other conceptual frameworks that do exist in literature and are used regularly are the Food Track and Trace Ontology (FTTO) (Pizzuti *et al*., 2014) and the TraceFood framework (Tracefood.org). Although many of these authors have established certain components of the traceability system, the main aim of this article is to establish a globally acceptable and easily understandable framework that can be adopted by role-players in the beef value chain, from abattoir to the consumer.

## 6.2 Methodology

Various conceptual frameworks for traceability can be found in literature. There is no common theoretical framework for the implantation of traceability in the food industry (Karlsen *et al*., 2013). Some of the conceptual frameworks found in literature are the Critical Tracking Event (CTE) and Key Data Element (KDE) model (Zhang and Bhatt, 2014; Welt and Blanchfield, 2012; Miller and Welt, 2014), The Food Track and Trace Ontology (FTTO) model (Badia-Melis *et al*.,2015; Pizzuti *et al*,. 2014), and the TraceFood framework (Storøy *et al.,* 2013; Tracefood.org.).

For the purpose of this article, the focus will be on abattoir-to-retail traceability for the domestic South African market, with standards that comply with international standards. The CTE and KDE framework of the Global Food Traceability Center compiled by Zhang and Bhatt (2014) will be used to establish an easily understandable traceability framework from abattoir to retail. Critical Tracking Events are defined as those points where a product is moved between premises and is transformed, or are determined to be points where data capture is important for effective tracing by the IFT Report of 2009. CTEs are divided into three categories which are transformation, transportation, and depletion, with each of these being divided into two further sub-categories. Transformation is divided into transformation input and transformation output, and transportation consists of shipping and receiving events. The depletion-type events consist of disposal and consumption. These six events will be used to establish the Critical Tracking Events for each of the role-players in the value chain, from the abattoir to the end consumer. After the CTEs are established, the key data that should be recorded at each CTE will be established.

According to the GS1 model for the adoption of CTEs in the meat supply chain, the key data elements should answer five questions about who has done the activity, when the activity was done, what products were involved, where the activity took place, and lastly, why the event was reported. These five questions will be used to establish all the KDEs for each CTE. The framework will then be tested against all the important global standards and regulations to ensure that it complies with these standards and regulations, and that the companies who introduce this framework will have access to prestigious exporting markets, such as the European Union and Japan.

These standards include the GS1 Global Traceability Standard, the ISO 22005:2007, the EC 1760 of 2000, and ICAR. As soon as the framework complies with these standards, the adopters of this framework will be able to export to most of the countries where the demand for beef products is high and where international traceability standards are required.

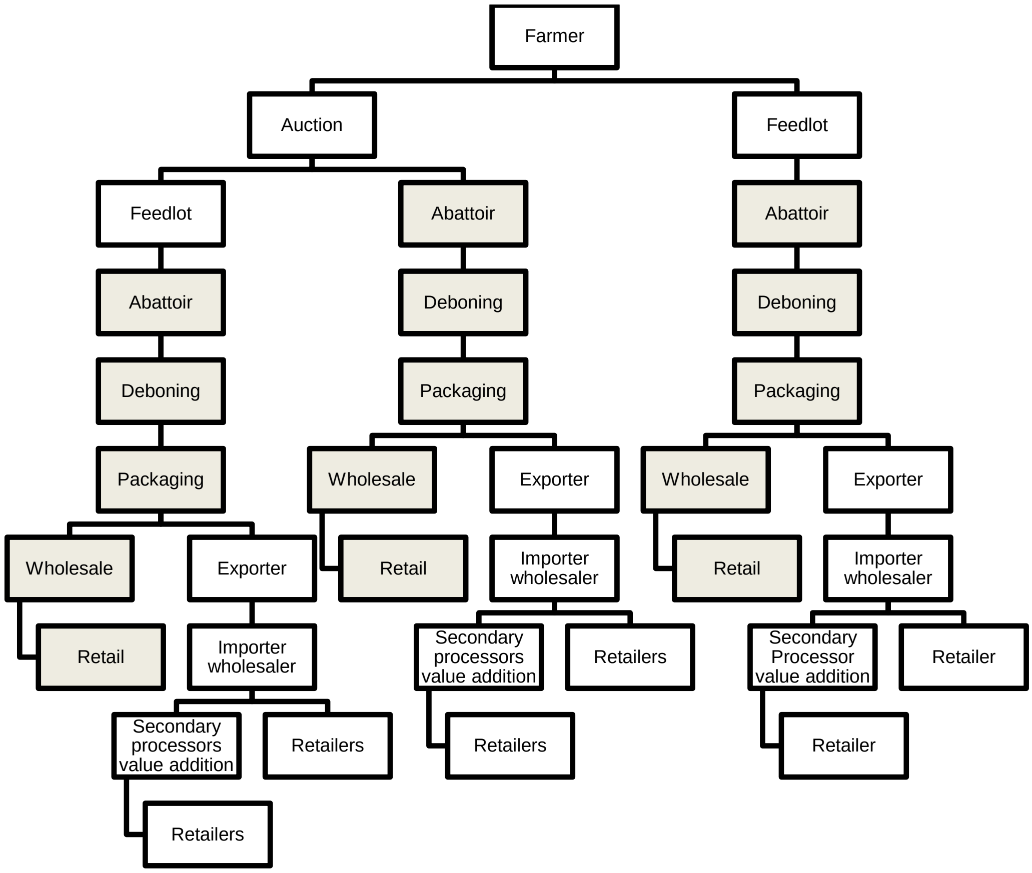


*Figure 6.1: Domestic and Exporting Beef Value Chain*

Source: Own illustration

## 6.3 Abattoir traceability

The abattoir is a crucial stop for each animal that will end up in the food chain. Abattoirs have various food safety regulations which they should comply with. One of the most well-known regulations used globally comprise Hazard Analysis and Critical Control Points (HACCP). HACCP is compulsory in South Africa and falls under the Foodstuffs, Cosmetics and disinfectants Act, 54 of 1972, the same act under which the Good Manufacturing Practices (GMP) falls. Another law, with its regulations, that plays a very important role is the Meat Safety Act, 40 of 2000, which includes the Red Meat Regulations (R1072). These regulations include provisions for the registration of abattoirs, export regulations, import regulations, treatment of condemned material, hygiene management and evaluation systems, hygiene requirements for persons entering abattoirs, meat inspections, classification and marketing, humane treatment of animals during the slaughter process, and lastly the slaughter of animals for personal or religious purposes and cultural consumption.

There are three main bodies which manage the implementation of these laws and regulations: the International Meat Quality Assurance Services (IMQAS), the South African Meat Industry Company (SAMIC), and the Red Meat Abattoir Association (RMAA). SAMIC is the body which carries out all the audits on the abattoirs, as well as the audits on products which are claimed to have specific attributes (Meat Safety Act). SAMIC also implements South Africa's current Grading and Classification System. Another law which plays an important role in abattoirs is the Consumer Protection Act, 68 of 2008. This Act is one of the main motivations for the adoption of traceability in the supply chain currently, as this Act promotes fair, accessible, and workable marketplaces for consumer products and services. This Act regulates the labelling, marketing and advertising of food products (among other things) to ensure that information is reliable and true and that no misleading marketing practices are used.

### 6.3.1 Framework for abattoir traceability

If one takes into account the process within an abattoir, there are certain Critical Tracking Events where Key Data should be captured. These CTEs include the arrival of the live animal, the slaughter of the animal, electric stimulation, the first grading of the animal, the removal of the hide, the removal of intestines, the inspection of the carcass, splitting of the carcass, Specific Risk Material (SRM) removal, second grading, the chilling process, the final grading of the carcass, and then lastly the departure of the carcass to its new destination, being a new owner or a deboning facility. The Key Data Elements that need to be recorded contain information on the history of the animal, as well as certain details that could be of assistance in the future, such as quality information and food safety information. The abattoir needs information on the history of the animal, for instance what it was fed, vaccinated for and what special attributes there are to the animal or product, for example grass-fed, organic, Angus beef, Karoo lamb, etc.

The Key Data Elements that need to be recorded at each Critical Tracking Event will be discussed in more depth, as indicated in Figure 6.2 below.

### 6.3.2 Arrival as a Critical Tracking Event at the abattoir.

The Key Data Elements that need to be recorded at this stage include the date of arrival, location of arrival, unique animal identification number, the herd/owner of origin, and the transportation vehicle registration number. This information will give the owner of the abattoir access to information on the origin and history of the animal, as well as giving assurance that the animal was not stolen and does not have any diseases that could be harmful to human health.

### 6.3.3 Slaughter as a Critical Tracking Event at the abattoir.

As with the arrival, there are also specific Key Data Elements that should be recorded with slaughter. This data influences the shelf life of the product, as well as the quality and safety of the product. These data elements include the date of slaughter, the time of slaughter, and the place of slaughter. The place of slaughter is important for ensuring that the animal was slaughtered at a registered abattoir which handles the carcass in the correct manner, according to the Red Meat Safety Act of 2000.

### 6.3.4 Electric stimulation as a Critical Tracking Event at the abattoir.

Electric stimulation is not used in all abattoirs, even though various researchers have indicated that electric stimulation does have an influence on the meat quality (Hwang, Devine and Hopkins, 2003; Adeyemi and Sazili, 2014; Nazli *et al*., 2010; McKenna *et al*., 2003; Hwang and Thompson, 2001). Electric stimulation is the transmission of electric current through a freshly slaughtered carcass in order to accelerate post-mortem glycolysis, which will cause a decline in pH that will help to improve meat quality.

Therefore, for level 1 traceability, it is important to indicate the following KDEs: whether electrical stimulation took place – Yes/No,

### 6.3.5 First classification as a Critical Tracking Event at the abattoir

The first classification of a carcass consists of age and sex classification. The sex of the animal can be divided into male and female, while age classification consists of A-class for young animals that have 0 permanent teeth. AB class is for slightly older animals that have 1-2 permanent teeth. B grade is for animals with 3–6 permanent teeth, while older animals with more than 6 permanent teeth will be C class. Therefore, the first KDE for first classification will be the age of the animal, according to the grades mentioned above. The second KDE will be the sex of the animal, where one needs to distinguish between male, female and castrated animals. These classes are all determined according to the Agricultural Product Standards Act, 119 of 1990, and it is according to this Act that SAMIC is tasked to classify carcasses.

### 6.3.6 Removal of hide as a Critical Tracking Event at the abattoir.

When the hide of the animal is removed, it is important that the hide should be tagged and identified. The KDE in this case will be the identification number that will be linked to the hide, and it is important that that hide can be linked to the carcass. In cases where there are problems and the carcass does not pass the inspection, it should be destroyed as it might hold a health risk to society. If this should occur, it is important that all parts of the animal can be traced and destroyed.

### 6.3.7 Removal of intestines as a Critical Tracking Event at the abattoir

When the intestines of an animal are removed, it is important that they can be traced until the animal passes the health inspection and one can be sure that the animal does not hold any possible health risks for consumers. Therefore, the KDE will be which animal intestines go into what batch when they are shipped away for further processing. These records should be kept in case of a recall.

### 6.3.8 Inspection of carcass as a Critical Tracking Event at the abattoir

A KDE at this CTE will be to indicate whether a carcass was pulled for inspection, and if it was, it is important to indicate whether the carcass passed the inspection or not. In cases where a carcass does not pass the inspection, it is important to indicate that it did not pass and the reasons why it did not pass.

### 6.3.9 Splitting of the carcass as Critical Tracking Event at the abattoir

After the carcass has been graded and has passed the inspection, the carcass will be split for easier handling. It is important that each half or quarter of the carcass be identified, and each identification code must be linked to the live animal's ID. Therefore, these IDs will be the KDE that needs to be linked to the original ID.

### 6.3.10 SRM removal as a Critical Tracking Event at the abattoir.

Over 1984–1987, an outbreak of Bovine Spongiform Encephalopathy (BSE) caused consumers to lose confidence in beef products in the United Kingdom (Souza-Monteiro and Caswell, 2004). BSE forms part of a group of diseases called transmissible spongiform encephalopathies (TSE) which are all diseases of the brain. These diseases are all zoonoses, and the human variant of BSE is Creutzfeldt-Jakob disease (CJD). Specific Risk Material (SRM) removal is seen as a precautionary method for averting the transmission of BSE to humans, as well as a method for stopping the spreading of BSE among animals. SRM is inedible and cannot be used in the production of human food. Globally, certain requirements are put in place by countries for the removal of SRM. Most countries require that the basic SRMs that need to be removed are the brain and the spinal cord of the animal. Therefore, for the purpose of traceability, the KDEs will be whether SRM removal took place or not.

### 6.3.11 Second classification as a Critical Tracking Event at the abattoir.

The Key Data Elements involved at the second classification of the carcass consists of the fat classification, the conformation of the carcass, and damage to the carcass. The fat classification will comprise a 0 class for a carcass with 0 mm layer of subcutaneous fat. A fat class of 1 will be a carcass with less than 1 mm layer of subcutaneous fat, and a class of 2 contains between 1 and 3 mm layer of subcutaneous fat. Classes of 3 and 4 have subcutaneous fat layers of between 3 and 5 mm and 5 to 7 mm, respectively. A class 6 is classified as excessive fat with a subcutaneous fat layer of more than 10 mm, while a class 5 will have between 7 and 10 mm subcutaneous fat layers, and are slightly over fat. The desired fat classes are 2 to 4, whereas 1 and 0 are too lean. Five conformation classes have been determined under the Agricultural Product Standards Act of 1990, which are class 1 for a carcass that is very flat and class 5 for a carcass that is very round, with 2, 3 and 4 being the in-between classes. It is also important to determine if there is any damage to the carcass.

#### 6.3.12 Chilling process as a Critical Tracking Event at the abattoir

During the chilling process, there are two main KDEs that play an important role, as they could influence meat quality and shelf life. These two KDEs are temperature and velocity. Therefore, it is important that the abattoir should indicate at what temperature and velocity the carcass was cooled.

#### 6.3.13 Final grading and maturing as a Critical Tracking Event at the abattoir

During the final grading in the abattoir, the chill lessor will measure the final tenderness of the meat to ensure that the meat has the required characteristics for its intended market. If meat is matured to enhance the tenderness, the required KDE will be the number of days taken for maturing.

#### 6.3.14 Departure as a Critical tracking event at the abattoir

On the departure of the carcass, it is important to record the ID of the carcass, date of departure, location of departure, location of arrival, and date of arrival of the carcass. In other words, it is the basic movement information.

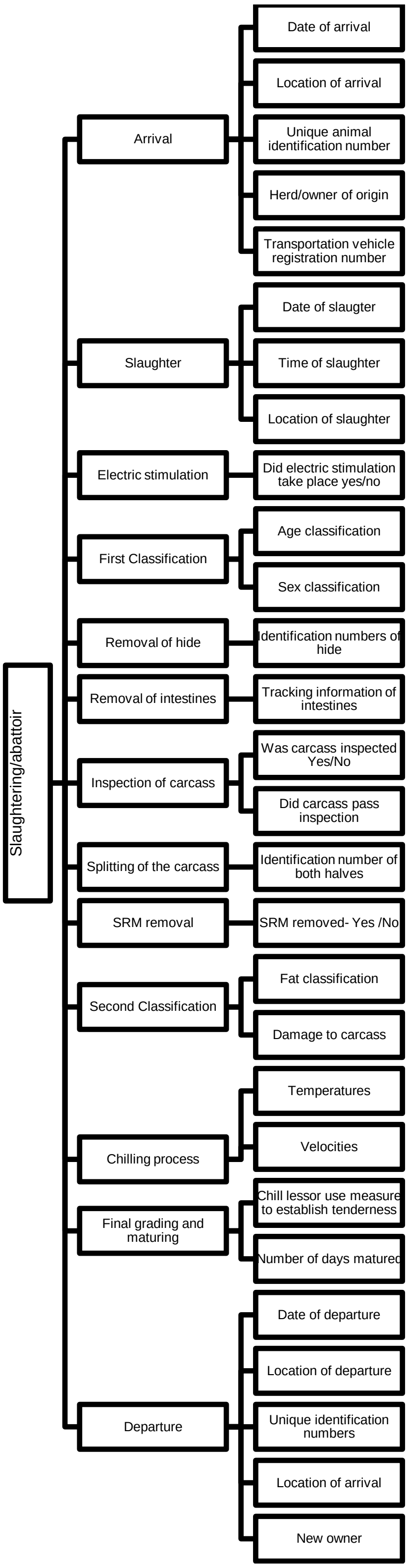


*Figure 6.2: Framework for traceability in the abattoir*

Source: Own illustration

#### 6.3.15 Benefits for the adoption of traceability at the abattoir

Various benefits for the adoption of traceability have been identified in previous studies. The following benefits were identified by Trautman, Goddard and Nilsson (2008):

- The occurrence of recalls will be reduced, which will reduce recall costs for abattoirs
- Traceability ensures food safety and enhances quality control
- Production of beef products can be coordinated and the flow of the products can be tracked more efficiently due to traceability
- In cases where food safety problems occur, the costs for solving the problem can be reduced.
- Information asymmetry of quality can be reduced because of traceability.
- The monitoring of upstream suppliers' activities leads to large transaction costs, and traceability helps with the reduction of these costs.

## 6.4 Deboning and packaging traceability

Some of the abattoirs have their own deboning facilities where they debone and pack certain meat cuts into boxes. Karan beef, Sparta and Beefmaster are some of the well-known South African feedlots who have integrated forward into the supply chain by having their own abattoirs and deboning facilities. Integration like this makes traceability easier to implement. At deboning facilities, the carcasses are usually deboned and processed into certain cuts for certain markets. There are cases where deboning facilities have different locations and owners, which makes it important to keep records of all such data, as well as of transfers. There are four main Critical Tracking Events in the deboning and packaging plants, which consist of arrival, product detail, packaging, and departure.

### 6.4.1 Arrival as a Critical Tracking Event

The basic Key Data Elements should be recorded as part of the arrival event. These events include date of arrival, location of arrival, time of arrival, and unique identification or batch/lot number. These data points are important for keeping track of where products came from, in case there is a recall on the product, or the product is not the quality it is supposed to be.

### 6.4.2 Processing as a Critical Tracking Event

In cases where products are processed further, it is important that records should be kept of all inputs used in the manufacturing of the product. The unique IDs of all the carcasses that are processed into a specific batch should be recorded. The new batch or Unique IDs of the meat after processing should be recorded. As various carcasses are deboned and processed, it can happen that cuts of various carcasses end up together, and therefore it is important to keep track of those combinations when they are packed together to ensure that in times a recall might occur

### 6.4.3 Packaging as a critical Tracking Event

After deboning, the meat might be packaged in small or large quantities, which are then sold to wholesalers and retailers. Therefore, packaging can be seen as a Critical Tracking Event. At this CTE, the important data should be recorded, such as the date and time of packaging, the batch/lot number of the packaging material, and the invoice number for the purchase of the packaging material. This information is important for cases where quality problems might occur with the packaging, which can be resolved by recalls. In cases like this, it would help to track other beef products packaged in the same packaging to ensure that no further recalls occur, as well as to hold the company who supplied the packaging responsible for possible losses.

### 6.4.4 Departure as a Critical Tracking Event

The departure is the same as other departure events. The KDEs consist of date of departure, time of departure, location of departure, name of the new owner, and lastly the unique product ID number/batch number.

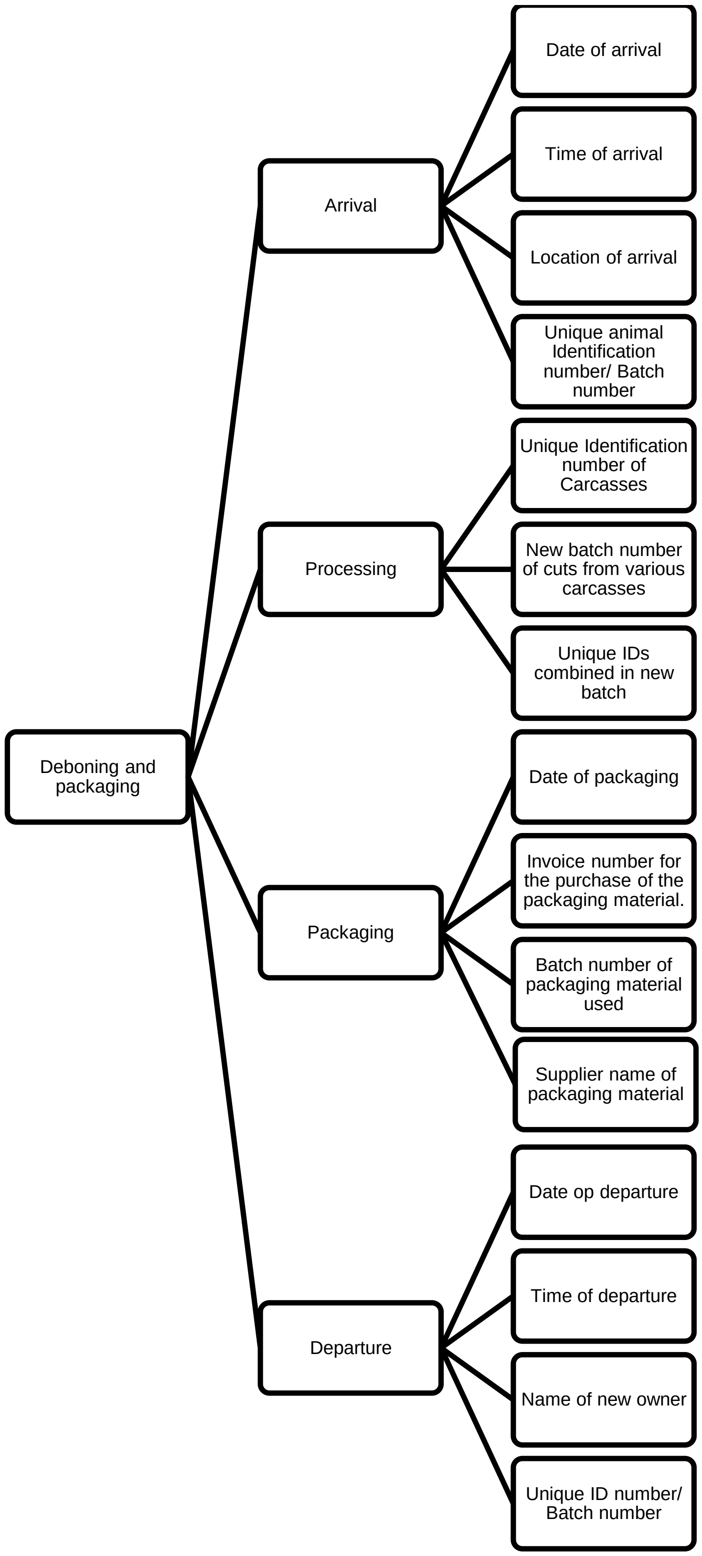


*Figure 6.3: Framework for Traceability at the Deboning and Packaging Plant*

Source: Own illustration

### 6.4.5 Benefits for the adoption of traceability at the processing plant

The benefits for a deboning and packaging plant, as identified by Trautman, Goddard and Nilsson, (2008) include a reduction in costs for the monitoring of upstream suppliers, insurance premiums, and a reduction of costs during the management of a food safety crisis, if one occurs. The other cost that could also be reduced due to traceability comprise recall costs, as all the sources of a product can be identified in time. Production can be coordinated, as the tracking of the flow of products can be done more efficiently.

## 6.5 Wholesale and retail traceability

### 6.5.1 Arrival as a Critical Tracking Event

The arrivals at the wholesaler and retailer are the same as other arrivals from other role-players in the value chain, and are therefore the same. The Key Data Elements that should be recorded for this event are date of arrival, time of arrival, invoice number, name of supplier, batch/lot number, and location of arrival. This data is important as it could be of assistance in cases where recalls occur, or if there might be a quality problem, because the contact information of the supplier is known, and from which batch and invoice. All this information is important in cases where losses have occurred and the suppliers should be held liable for the losses or possible claims.

### 6.5.2 Transformation input as a Critical Tracking Event

It might happen that products which were sold in bulk to wholesalers or retailers are repacked in smaller packages, or the meat is marinated or transformed into other products. In these cases, there will be certain inputs that will enter the transformation process, and so it is important to record specific Key Data Elements for each of these transformation processes. These KDEs will include batch/lot number of the input, date of transformation, and time of transformation. This data will be important in cases where problems might occur in the transformation process and the wholesaler or retailer would need to recall all the products in time or to identify the problem in time, before more products are contaminated.

### 6.5.3 Transformation output as a Critical Tracking Event

In cases where the product was transformed in the retail or wholesale sector, it is important to record the new batch/lot number of the product – in this case, the packed beef. Other key data elements that should also be recorded are the sell-by date and the use-by date, which should be on the label of the product. The transformation input and the transformation output should always be linked to trace cases where problems might occur in the manufacturing process. After the occurrence of such a problem, it is important to be able to track all products manufactured, or cases which form part of a specific batch, as those products should be recalled as quickly as possible before the contaminated products reach the consumers. This is especially important for the retailers as they sell directly to the consumer.

### 6.5.4 Departure as a Critical Tracking Event

At the departure event, the product can either be sold as an input which can be used in the production of other food products, as in the case of wholesale, or be sold directly to the consumer for consumption, as with retailers. In these cases, the KDEs that need to be recorded are date of departure/selling date, time of departure/sale, location of departure/sale, and lastly the new owner, if the product was sold to the consumer for consumption.

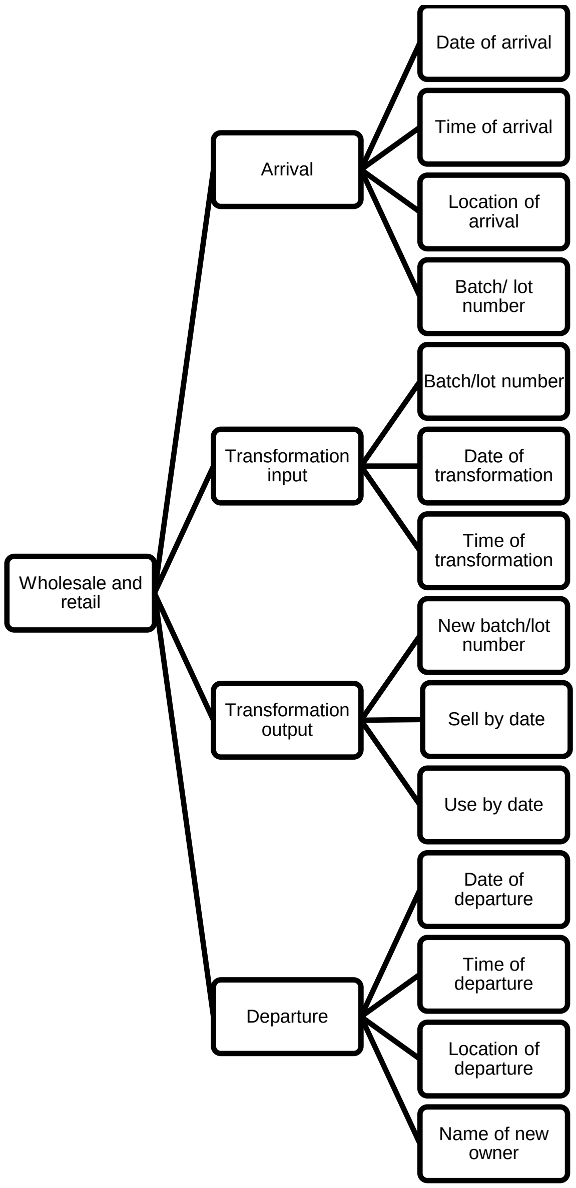


*Figure 6.4: Framework for Traceability at Retail or Wholesale*

Source: Own illustration

### 6.5.5 Benefits for the adoption of traceability at wholesale and retail levels

One of the biggest benefits for the adoption of traceability at the wholesale or the retail level will be the enhancing of consumer or buyer confidence, as consumer confidence has been the main motivation for the implementation of mandatory traceability systems in a number of countries. The companies' risk to exposure will be reduced, as traceability helps to identify all the sources of a product. This will reduce recall costs, which adds an additional benefit, while other transaction costs that can be reduced will be the costs of monitoring the activities of upstream suppliers, as well as insurance premiums that should be lower. Some companies have saved up to 5 hours a week on labour after introducing traceability, which is another added benefit (Trautman, Goddard and Nilsson, 2008).

## 6.6 Traceability benefits for the consumers, government and the public

Traceability has huge benefits for the public, such as a reduction in the occurrences of food-borne illness. In cases where these outbreaks of food-borne illnesses or animal diseases take place, traceability makes it possible to identify these threats and occurrences, and to introduce safety measures immediately. With good traceability systems in place, it is possible for governments to prevent the slaughter of animals that are not fit for human consumption, thus protecting public health. The management of contagious diseases will also improve at national and regional levels. The data recorded by virtue of traceability can be used for further research, as well as to establish a strategy for improving the quality of the entire industry **(**Trautman, Goddard and Nilsson, 2008).

## 6.7 Traceability as a tool for consumer communication.

In recent years, the regulations about the labelling of products have changed. Many questions exist on what information consumers see as important and how this influences their purchasing behaviour. In studies conducted in recent years, much research has been done on consumers' requests for quality information on beef labels. The results of some of these studies have indicated that information regarding meat quality has improved consumers' perceptions (Henson and Northen, 2000; Verbeke, 2001; Steenkamp and Van Trijp, 1996; Herrmann, Krischik-Bautz and Anders, 2002). European consumers in four countries have indicated that they would require more detailed traceability information for new, unfamiliar products, as well as for fresh produce which includes meat. Most of the respondents indicated that they prefer the information to appear on the product itself, rather than next to the product or at the point of sale (Van Rijswijk and Frewer, 2012). Gellynck and Verbeke (2001) reported, in a study where they tested Belgian consumers' perceptions of traceability, that they concluded that functional attributes obtained the highest score. Functional attributes included the monitoring of the meat supply chain, as well as the responsible individuals. The process attributes, which included production information, scored lower. Verbeke and Ward (2006) conducted a study where they measured the registered value consumers have for certain information that can be found on labels, before and after they conducted an information campaign to educate the consumers on what this information entails. Before the campaign, consumers did not give much attention to certain information, such as the country-of-origin or traceability reference code. However, after they conducted the information sessions, consumers did focus more on quality guarantees, traceability, and country of origin. Loureiro and Umberger (2007) found, in a study they conducted on US consumers, that the consumers were more willing to pay a bigger premium for COOL than for traceability. COOL can only be seen as a quality or safety signal if the source of origin is known for having higher food safety or better quality than other sources have. Therefore, it is clear that traceability can be an effective tool for communicating certain information to consumers, but for that to be successful, it is important that the consumers should be educated first.

## 6.8 The economic implications of traceability.

Various estimates exist on the costs for the implementation of a farm-to-fork traceability system. Buhr (2002) estimated the cost for a single supply chain to implement a farm-to-fork traceability system in Europe to be approximately $10–12 million. The implementation of such a system will only be possible if the costs are obtained from somewhere else or if the benefits exceed the costs, and only then will the implementation of such a system be economically feasible. In literature, various studies report on the benefits for the adoption of traceability, as well as on consumers' willingness to pay. A combination of these show that it is economically feasible, as well as beneficial, to implement such a system.

Some real world case studies indicate that it is certainly beneficial for companies to adopt traceability. Companies do not adopt traceability systems only to comply with demands from market, and for some, the motivation is rather to increase efficiency. Tyson Foods has increased the quantity shipped out of their distribution centres from 600 000 000 in 1995 to almost 1 200 000 000 in 2010, while the labour has remained constant (Lothian, 2015).

The Enright Cattle Company increased their operational efficiency, as follows (Bhatt, 2015):

- 16 % increase in sales volume
- 17 % decrease in overall operating costs
- 18 % decrease in labour costs
- The return on investment, based on increased sales and operational efficiencies, was 37 % with the payback period being approximately 9 months
- When a mock recall exercise had been done in the past, it took approximately 48 hours to recall100 % of the meat, but after the adoption of traceability, it took only a few minutes.

Research has been done on consumers' perceptions on traceability, and whether they were willing to pay for traceability. The results differ much between the case studies. In a study done by Dickenson, Hobbs and Bailey (2003), they established what premiums consumers were willing to pay on a sandwich in the United States of America and in Canada, respectively. The premium was measured on four attributes, namely humane animal treatment, food safety assurance, traceability, and all three of these attributes combined. The same attributes were used to establish the premiums for only the ham. The results were as follows:

*Table 6.1: Consumers' Willingness to Pay for Certain Attributes*

| | |
|---|---|
| **United States of America Sandwich** | |
| **Attribute** | **Premium** |
| Humane treatment of the animal | US$0.48 |
| Food safety assurance | US$0.60 |
| Traceability | US$0.21 |
| All three attributes | US$1.05 |
| **United States of America Ham** | |
| **Attribute** | **Premium** |
| Humane treatment of the animal | US$0.60 |
| Food Safety assurance | US$0.69 |
| Traceability | US$0.54 |
| All three attributes | US$1.29 |
| **Canada Sandwich** | |
| **Attributes** | **Premium** |

| | |
|---|---|
| Humane treatment of the animal | CND$0.95 |
| Food safety assurance | CND$0.90 |
| Traceability | CND$0.45 |
| All three attributes | CND$1.85 |
| **Canada Ham** | |
| **Attribute** | **Premium** |
| Humane treatment of the animal | CND$0.65 |
| Food safety assurance | CND$0.65 |
| Traceability | CND$0.35 |
| All three attributes | CND$1.05 |

(Source: Dickinson, Hobbs and Bailey, 2003)

In this study, it is clear that although consumers are willing to pay a premium for traceability, this is proportionally less than for other attributes, such as the humane treatment of animals and food safety assurance. The three attributes together are preferred, rather than each attribute on its own.

Dessureault (2006) indicated that the probability of costs being equal to perceived benefits was increased by 27.4 % when traceability was implemented to gain access to new markets. The probability is bigger than 0.1.

## 6.9 Conclusion

It is important for countries and businesses to adopt a globally acceptable traceability system to ensure that they stay competitive in the global market. The CTE and KDE framework assists in establishing a framework which is easily understandable for countries or companies who wish to start a traceability system, but do not want to do extensive research. For the part of the system from abattoir to slaughter, there are various health and safety requirements that need to be taken in consideration to ensure that quality is not jeopardised, to ensure food safety, and manage contamination. For a traceability system to be successful, it is necessary to communicate information about the production of the product to consumers to help build consumer confidence in the products.

Implementing such a system means that exporters can skip the retail and wholesale sector locally, and the meat can be exported to countries directly from deboning and packaged in the form of boxed beef. The exporters and importers can apply the same framework for further transformation and packaging as is used in the domestic market by the wholesalers and retailers.

There are also many benefits to be gained for each of these role-players when adopting traceability, and these benefits can be seen as comprising a motivation for the adoption of a voluntarily traceability system. This framework takes the South African Grading and Classification into account to ensure that the framework complies with the South African regulations in the Agricultural Products Act. Accordingly, companies in South Africa who wish to adopt the proposed traceability system will also comply with the local regulations.

## 6.10 References


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# Chapter 7 Summary and Conclusion

## 7.1 Summary

Throughout recent years, the number of food scares has increased internationally. Countries started implementing traceability systems in an attempt to manage food safety risks and regain consumers' confidence in certain food products. Therefore, traceability has become an important requirement in the food industry, and in the beef industry as well.

Some of the bigger importing and beef producing countries have implemented mandatory traceability systems, with the USA being an exception in its implementation of a voluntary beef traceability system. Research was done on the traceability systems of the European Union, Australia, Namibia, Botswana, Japan, the USA and Brazil, but there is a gap in research on beef traceability in South Africa. Traceability research done in South Africa has focused mostly on Karoo lamb and the export fruit industry. South Africa is already exporting increasing quantities of beef to African and Middle Eastern countries, but due to the lack of a traceability system that complies with international standards, it is still excluded from other markets. Traceability is an important requirement for beef exports and there are many opportunities for the South African beef industry to benefit from the growing global demand for beef products, especially high-quality cuts.

Those parties who wish to export beef will be able to export to those countries as soon as an internationally acceptable voluntary beef traceability system has been adopted by South Africa, as the USA has done. As brands and quality indicators are becoming more important in the South African beef market, traceability can be used as a marketing tool to ensure the constant supply of the same quality products as are preferred by consumers, while these companies can overcome non-tariff barriers such as traceability requirements.

The main aim of this study was to establish a feasible, voluntary, internationally acceptable beef traceability system for South Africa. A subsidiary aim of this study was to gain a better understanding of what the current status of beef traceability is globally, and what the requirements would be for a globally acceptable system. At the same time, it was important to understand what local laws and regulations influence the local beef industry, and what global requirements should be added. After establishing the requirements, the various traceability conceptual frameworks that might assist in the establishment of a voluntary beef traceability system for South Africa were studied.

The three main focus areas for the global overview were surveyed in three steps, with the first step being the formation of an overview of the systems adopted by the biggest importing and exporting countries, as well as the evaluation of the depth, breadth and precision of their systems. The second step in the global overview was to understand the requirements needed to comply with the well-known traceability standards, such as GS1, ISO, ICAR and the European Food Law. The final step was to study the three conceptual frameworks for traceability found in literature, namely: the TraceFood framework, the Food Track and Trace Ontology, and lastly, the CTE and KDE framework. This information was used to develop a voluntary system for the establishment of a beef traceability system for South Africa. The chosen framework was the CTE and KDE framework, as used by Zhang and Bhatt (2014) in the guidance document for traceability adoption.

This framework was used in conjunction with the value chain model of Will (2004) and Roduner (2005) to establish the CTEs and KDEs for each role-player in the South African beef industry, as well as to ensure that these CTEs and KDEs comply with domestic requirements. In following this process, it became evident that some of the requirements for a traceability system are already covered by South African laws and regulations, for example anyone moving a live animal or meat should be in the possession of a movement certificate which captures the information required for traceability purposes. The CTE and KDE framework was the ideal framework, as it is very similar to the HACCP framework which identifies critical control points.

Once the framework was established, it was made clear that the benefits from adopting a traceability system stretch much wider than only accessing new markets. Other benefits include food safety and farmers' gaining access to management data which can be used in the making of production decisions. Other benefits also include the building and management of brands and the protection of brand reputation.

Traceability can assist in branding because it is a good tool for quality management, as it is important to produce the same quality at all times, and in cases where something goes wrong with the quality, a recall can be easily done and possible damage to the brand reputation can be minimised.

Other benefits of traceability include the point that it can enhance animal health while reducing the economic impact of disease outbreaks, especially for developing countries. Animal diseases, such as brucellosis, tuberculosis and foot-and-mouth disease, are causing huge financial losses in developing countries, and traceability could assist in identifying problem areas, while preventing any further spreading of disease. In South Africa, traceability could play a huge role in preventing brucellosis from spreading any further and causing larger economic losses.

The potential for achieving possible price premiums by primary producers cannot be excluded, as transparency in the value chain will be enhanced. Other role-players in the value chain will have greater access to performance records of live animals, while farmers will have access to carcass feedback information which could then be used for selection decisions. Other advantages include enhanced efficiency and the reduction of incentives to cheat.

The National Animal Identification System (NAIS) on the cost–benefit analysis for the adoption of a traceability system is a good example of the financial and economic benefits of traceability systems. Other benefits for secondary role-players include the reduction of information asymmetry and the coordination of the flow of products, which ensure quality control. The economic benefits for the secondary role-players include reduced recall costs and a reduction in transaction costs and liability claims. A very good real time example of the economic benefits for the adoption of traceability is the case study of the Enright Cattle Company. This company increased its sales volume by 16 % with a cut of 17 % in overall operational costs, and the payback period was only 9 months, with a return on investment of 37 %.

Some of the other benefits for this framework are that the management of data for all role-players, market access, consumer preferences and communication can be enhanced. Moreover, financial institutions which provide livestock loans could require that the borrowers adopt this system and thereby gain more control over the livestock, as well as movement and sales of the livestock, thus acquiring a form of security for the loans.

It is possible to adopt a voluntary beef traceability system and gain access to all the benefits of a mandatory traceability system. The use of the CTE and KDE framework ensures that a uniform language is created along the value chain for traceability, and interoperability is enhanced in the process, together with the provision of a good focus on quality control and consumer communication, while still complying with the current South African laws.

This framework is also internationally acceptable, and comprises three main component areas, namely farmer to feedlot, feedlot to abattoir, and abattoir to retailer. The proposed system will also address South Africa's current crisis with herd health caused by extensive outbreaks of brucellosis and tuberculosis, which renders South Africa a high-risk country. Therefore, one can conclude that the benefits from the adoption of the proposed framework far exceed the costs.

From an economic perspective, some real world case studies show clearly why it is economically feasible to adopt traceability with examples like the Enright Cattle Company which increased their sales volumes by 16 % while decreasing their overall operating costs by 17 %. The company's return on investment, based on increased sales and operational efficiency, was 37 % with a payback period of only 9 months.

Other studies that focused on consumers' willingness to pay have also indicated that consumers are willing to pay for a combination of attributes, for example food safety assurance, traceability, and animal treatment, with the largest willingness to pay being for all three attributes, rather than for individual attributes. Therefore, the proposed framework can act as an important tool for ensuring that consumers have access to the required information.

## 7.2 Conclusions

It is important for countries and businesses to adopt a globally acceptable traceability system to ensure that they stay competitive in the global market. The CTE and KDE framework assisted in establishing a framework which is easily understandable for countries or companies that wish to start a traceability system, but do not want to do extensive research. It is possible and beneficial to adopt a voluntary beef traceability system for South Africa, before any implementation of a mandatory system at a later stage. The voluntary system can be seen as a pilot study, to be used while the industry becomes accustomed to traceability and to allow participants to see the benefits of traceability. The role-players participating in the voluntary system do so out of their own volition and will thus be more motivated to make the system work and to do so more efficiently. For the part of the system from abattoir to retail, there are various health and safety requirements that need to be taken in consideration to ensure that quality is not jeopardised and to ensure food safety and manage contamination. For a traceability system to be successful, it is necessary to communicate information about the production of the product to consumers to help build consumers' confidence in products.

Implementing such a system means that exporters can skip the retail and wholesale sector locally, and the meat can be exported to countries directly from deboning and packaging plants in the form of boxed beef. The exporters and importers can apply the same framework for further transformation and packaging, as used in the domestic market by the wholesalers and retailers.

The proposed framework has taken the South African classification system into account to ensure that the framework complies with the South African Regulations in the Agricultural Products Act. Therefore, companies in South Africa that wish to adopt the proposed traceability system will, in doing so, also comply with local regulations.

Even when complying with South African as well as global regulations, there are still various challenges that come with the implementation of a traceability system. The South African beef industry does not differ from other developing countries in the challenges it will face with the implementation of a traceability system. Some of these challenges include the following:

- Some role-players might believe that there are little economic benefits in adopting a traceability system, as they perceive the benefits to comprise a price premium.
- The implementation of a traceability system is quite costly and requires high investment costs. In South Africa, financial resources are restricted.

- In South Africa, livestock still play an important role in certain cultures. For that reason, many of the subsistence farmers in South Africa own livestock which are never sold into the formal food industry, but are rather sold for traditional purposes at funerals and weddings. This might complicate the data capturing surrounding the deaths of these animals. In the case of a mandatory system, one could then have thousands of animals each year in the National Database that are slaughtered or have died, and this is never reported.

Therefore, one can conclude that the main objective of this study has been reached by developing a voluntary beef traceability system for South Africa that is feasible and globally acceptable. It is my opinion that the South African beef industry is not yet ready for a mandatory system, as the benefits of traceability in monetary value is not yet clear.

## 7.3 Recommendations

Further research could be done on a post-slaughter traceability framework, as more detailed KDEs can be established, as well as building in Key Data Elements which could assist in the implementation of a more advanced grading system, such as the Meat Standards Australia system.

Further research could also be conducted on how the proposed traceability framework might assist in improving the South African cattle herd, as well as on how to establish a cost–benefit analysis for the South African beef industry and thereby establish the financial benefits for the adoption of this framework. Research could be done on how to adopt the proposed framework to establish a framework for voluntary traceability systems in the mutton and venison industries, where South Africa has the potential to gain access to elite export markets.

*Table 7.1 Framework for a Voluntary Beef Traceability Framework*

| **Role-Player** | **Critical Tracking Events** | **Key Data Elements Level 1** | **Key Data Elements Level 2** | **Key Data Elements Level 3** |
|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Farmer | Birth | | Unique Animal Identification number, Month of birth, Breed of the animal and herd of origin | Unique Animal Identification number, Date of birth, Breed of the animal and herd of origin, Dam's Unique ID | Unique Animal Identification number, Date of birth, Breed of the animal and herd of origin, Dam's unique ID |
| | Health | Tests | Date of Test, Disease tested for, Veterinarian testing, Results | Date of Test, Disease tested for, Veterinarian testing, Results | Date of Test, Disease tested for, Veterinarian testing, Results |
| | | Products | Name of Product, Date of usage, Animal ID | Name of Product, Date of usage, Animal ID, Amount used | Name of Product, Date of usage, Animal ID, Amount used, Batch number |
| | Feed | | Product used, any medication contained | Product used, any medication contained, date of usage | Product used, any medication contained, date of usage, Batch number |
| | Movement | | Departure location, departure date, vehicle registration number, arrival location, arrival date | Departure location, departure date, vehicle registration number, arrival location, arrival date | Departure location, departure date, vehicle registration number, arrival location, arrival date |
| | Disposal | | Date of disposal, reason for disposal, location of disposal | Date of disposal, reason for disposal, location of disposal | Date of disposal, reason for disposal, location of disposal |

| | | | | | |
|---|---|---|---|---|---|
| Auction | Arrival | | Date of arrival, location of arrival, herd/owner of origin, Unique ID, Transportation vehicle registration number | Date of arrival, location of arrival, herd/owner of origin, Unique ID, Transportation vehicle registration number | Date of arrival, location of arrival, herd/owner of origin, Unique ID, Transportation vehicle registration number |
| | Departure | | Date of departure, Location of departure, Unique ID, Location of arrival, new owner at arrival, vehicle registration number | Date of departure, Location of departure, Unique ID, Location of arrival, new owner at arrival, vehicle registration number | Date of departure, Location of departure, Unique ID, Location of arrival, new owner at arrival, vehicle registration number |
| Feedlot | Arrival | | Date of arrival, Location of arrival, herd/owner of origin, Unique ID, Transportation vehicle registration number | Date of arrival, Location of arrival, herd/owner of origin, Unique ID, Transportation vehicle registration number | Date of arrival, Location of arrival, herd/owner of origin, Unique ID, Transportation vehicle registration number |
| | Feed | | Product used, Any medication contained | Product used, Any medication contained, Date of usage | Product used, Any medication contained, Date of usage, Batch number |
| | Health | Tests | Date of test, Disease tested for, veterinarian testing, Results | Date of test, Disease tested for, veterinarian testing, Results | Date of test, Disease tested for, veterinarian testing, Results |
| | | Products | Name of product, Date of usage, Animal ID | Name of Product, Date of usage, Animal ID, Amount used | Name of product, Date of usage, Animal ID, Amount used, Batch number |

| | | | | |
|---|---|---|---|---|
| | Disposal | Date of disposal, Reason for disposal, Location of disposal | Date of disposal, Reason for disposal, Location of disposal | Date of disposal, Reason for disposal, Location of disposal |
| | Movement | Date of departure, location of departure, Unique ID, location of arrival, new owner at arrival, vehicle registration number | Date of departure, location of departure, Unique ID, location of arrival, new owner at arrival, vehicle registration number | Date of departure, location of departure, Unique ID, location of arrival, new owner at arrival, vehicle registration number |
| Abattoir | Arrival | Date of arrival, location of arrival, herd/owner of origin, Unique ID, Transportation vehicle registration number | Date of arrival, location of arrival, herd/owner of origin, Unique ID, Transportation vehicle registration number | Date of arrival, location of arrival, herd/owner of origin, Unique ID, Transportation vehicle registration number |
| | Slaughter | Date of slaughter, time of slaughter and location of slaughter | Date of slaughter, time of slaughter and location of slaughter | Date of slaughter, time of slaughter and location of slaughter |
| | Electric stimulation | Did electric stimulation take place, Yes/No | Did electric stimulation take place, Yes/No | Did electric stimulation take place, Yes/No |
| | First Classification | Age and Sex classification | Age and Sex classification | Age and Sex classification |
| | Removal of Hide | Identification number of hide | Identification number of hide | Identification number of hide |
| | Removal of intestines | Tracking information of intestines | Tracking information of intestines | Tracking information of intestines |
| | Inspection of carcass | Was the carcass inspected, results of inspection | Was the carcass inspected, results of inspection | Was the carcass inspected, results of inspection |

| | | | | |
|---|---|---|---|---|
| | Splitting of the carcass | Identification number of both halves | Identification number of both halves | Identification number of both halves |
| | SRM removal | Did SRM removal take place, Yes/No | Did SRM removal take place, Yes/No | Did SRM removal take place, Yes/No |
| | Second classification | Fat classification, Damage to carcass | Fat classification, Damage to carcass | Fat classification, Damage to carcass |
| | Chilling process | Temperature and velocity | Temperature and velocity | Temperature and velocity |
| | Maturing | Number of days matured | Number of days matured | Number of days matured |
| | Departure | Date of departure, Unique ID, Location of arrival, new owner at arrival, vehicle registration number | Date of departure, Unique ID, Location of arrival, new owner at arrival, vehicle registration number | Date of departure, Unique ID, Location of arrival, new owner at arrival, vehicle registration number |
| *Deboning and packaging* | Arrival | Date of arrival, time of arrival, location and Unique ID/Batch number | Date of arrival, time of arrival, location and Unique ID/Batch number | Date of arrival, time of arrival, location and Unique ID/Batch number |
| | Processing | Unique ID, New batch number | Unique ID, New batch number | Unique ID, New batch number |
| | Packaging | Date, Invoice number, Batch number of packaging material and supplier of batch | Date, Invoice number, Batch number of packaging material and supplier of batch | Date, Invoice number, Batch number of packaging material and supplier of batch |
| | Departure | Date, Time, Name of new owner, Unique ID/Batch number | Date, Time, Name of new owner, Unique ID/Batch number | Date, Time, Name of new owner, Unique ID/Batch number |
| Retail and wholesale | Arrival | Date of arrival, time of arrival, location of arrival, Unique ID/Batch number | Date of arrival, time of arrival, location of arrival, Unique ID/Batch number | Date of arrival, time of arrival, location of arrival, Unique ID/Batch number |

| | | | | |
|---|---|---|---|---|
| | Transformation input | Batch/lot number, Date of transformation, time of transformation | Batch/lot number, Date of transformation, time of transformation | Batch/lot number, Date of transformation, time of transformation |
| | Transformation output | New batch/lot number, sell-by date, use-by date | New batch/lot number, sell-by date, use-by date | New batch/lot number, sell-by date, use-by date |

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