An assessment of the current state of traceability of South African retailers in the fresh vegetable supply chain

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Declaration

I declare that this dissertation is my own, unaided work. It is being submitted to the degree of Master of Science in Industrial Engineering to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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3rd day of November 2014

Abstract

Traceability has become a global requirement in the fresh food supply chain to ensure safety and quality of exports, imports and food grown and processed for local consumption. The objectives of this research were to establish the current state of traceability in South Africa, the constraints faced by those in the fresh vegetable supply chain and the implications of the current state.

The developed theoretical framework, derived from the literature review, for assessing the current state of traceability included the measurement of traceability, an evaluation of five supply chain enablers which are, information management, product management, quality assurance, buyer-supplier relationships and certification and compliance, and identification of constraints to traceability in South Africa. The research concluded that the fresh vegetable supply chain in South Africa was partly traceable. This was obtained from the results of the interviews analysed. To evaluate the state of traceability, six aspects of traceability had to be fulfilled by every participant in the supply chain which were; 1) product traceability, 2) process traceability, 3) genetic traceability, 4) inputs traceability, 5) disease and pest traceability and 6) measurement traceability. Constraints identified were, time it took to obtain results for maximum residue and microbial tests, liability due to sharing information hence exposing themselves, cost of testing produce and certification, competition as other markets besides the retailers exist, age and education of farmers as they are unable to use technology, legislation as a number of certifications exist, management of loose produce during processing and selling, and consumer awareness as no recorded incidence of contamination exist. The differences in the supply chains had no impact on the state of traceability.

The research followed a qualitative approach. A case study approach was implemented as a research strategy. South Africa has five major retailers who sell general merchandise and fresh fruit and vegetables to consumers. Case studies of three retailers in South Africa were carried out. Interviews and observations were used as the methods for gathering data. The data was analysed using gap analysis for measurement of traceability and the five supply chain enablers. Content analysis was used

to analyse the constraints in traceability. The differences in the supply chains of the retailers under study was noted and each participant in the supply chain which were the farmer, packing facility, transport providers, fresh produce market and retailers gave insight into the functions and processes they performed in the fresh vegetable industry.

The study hopes to aid the retailers in issues that need to be addressed to implement full traceability, assist farmers in building mutually beneficial relationships and addressing the constraints they all face.

Dedication

To Abel, Kayla and Nicole, your love keeps me going.

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Table of Contents

List of Figures

List of Tables

Abbreviations

APS	Agricultural Product Standards
AVL	Automatic Vehicle Location
BAFPS	Bureau of Agriculture and Fisheries Product Standards
DNA	Deoxyribonucleic Acid
FAO	Food and Agricultural Organisation
FBO	Food Business Operator
FDA	Food and Drug Administration
FSMA	Food Safety Modernisation Act
FSI	Food Safety Initiative
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GMO	Genetically Modified Organisms
GPS	Global Positioning Systems
HACCP	Hazard Analysis Critical Control Point
HRMAS-NMR	High Resolution Magic Angle Spinning Nuclear Magnetic Resonance
MRL	Maximum Residue Limits
NIST	National Institute of Standards Technology
OECD	Organisation for Economic Cooperation and Development
T-SOP	Traceability Standard Operating System
UNECE	United Nations Economic Commission for Europe
WHO	World Health Organisation

1. Introduction

1.1 Introduction

Traceability can be defined as "*the ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications*" (Olsen and Borit, 2013).

Traceability has become an essential aspect in the food industry. This is due to the need for quick and efficient food recalls in the case of chemical contamination or spoilage due to micro bacteria. According to Opara (2002) consumers are now more concerned with where their food comes from and what it contains, such as genetically modified organisms (GMO), sustainable methods of production and health reasons (van Rijswijk*, et al*. 2008). Companies on the other hand benefit from traceability by ensuring product safety, guarantee to consumers and a better understanding of the supply chain. Popper, (2007) highlights the benefits of traceability as accountability for chemical residues, inventory control, quality assurance, and protection from theft and fraud.

Food traceability is mainly driven by quality, sustainability, legislation, food safety, certification, bioterrorist threats, production optimisation, welfare, competitive advantage and chain communication (Bollen, 2009, Florkowski, *et al*. 2009, Karlsen, *et al.* 2013).

The need for technological innovations in agriculture is stressed by Opara (2002) and that it benefits all stakeholders in the food supply chain.

The South African Department of Agriculture issued Traceability Operating Guidelines (T-SOP) on 13 June 2007 that are applied to export only. These guidelines apply to regulated products of plant origin such as fruit and vegetables which are regulated by the Agricultural Product Standards (APS) Act of 1990 (Act 119 of 1990). The South African standards that exist are, food hygiene and food safety standards that are in the APS act, Standard Operating Procedures (SOPs) for Maximum Residue Limits

(MRLs) and Export Certificates (Department of Agriculture, 2007). No guidelines currently exist for traceability of locally sold produce in the fresh fruit and vegetable supply chain.

1.2 Motivation for the Research

Consumer demands for traceable food have led to the adoption of traceability systems for the food supply chain that offer information on the presence of chemical residue, absence of genetically modified organisms (GMO), proof of high speciality foods such as organic produce and lack of health and safety risks (Storøy, *et al.* 2013).

Weinberger and Lumpkin (2007) argue that more research in the area of horticulture, with emphasis on fresh fruit and vegetables is required and policies should focus on these researches to improve the agricultural industry. With the increase in added value in the food processing industry due to packaging and processing of fresh fruits and vegetables there is more interest in agribusiness (Weinberger and Lumpkin, 2007), thus this research focuses on the supply chain in the retail industry which packages and processes fresh vegetables. According to Madevu (2006) cut and packaged fresh fruit and vegetables that are available in South African supermarkets are a growing part of the food supply chain. Louw, *et al*. (2007) states that in South Africa the sale of fresh vegetables has moved from the fresh produce market wholesalers to retailers who have expanded into townships, due to establishment of franchises and more retail chains, which has displaced hawkers and green grocers that have traditionally supplied fresh fruit and vegetables to the consumer.

Liao *et al.* (2011), in a study on failure of traceability in Taiwan states that less information is known about fruit and vegetable farmers and their traceability systems or lack thereof. This has influenced the need for this research to focus on fresh vegetables sold in supermarkets and how they are sourced, prepared, packaged and transported. The study will focus on the issue of traceability in the fresh vegetable supply chain, which will include the use or lack of technology by retailers and suppliers to

ensure an efficient and reliable system. Fresh fruit has a much higher level of regulation associated with it due to exports and it is much more worthwhile to explore vegetables which have less regulation and are therefore more of a concern.

According to Karlsen, *et al.* (2013), Riden and Bollen, (2007), the lack of a common theoretical framework is a problem in the implementation of traceability. Without the common theoretical framework there is no basis for comparison or measure at what level a traceability system is performing. It is also difficult for companies to make decisions to implement food traceability as no cost and benefit analysis already exists which will aid them in decision making.

Quality and safety standards have become increasingly important in the fresh produce industry. According to Berdegue', *et al*. (2005) not enough literature exists on the emergence of quality and safety standards being employed by supermarkets in developing countries. Mostly, farmers adhere to traceability standards for export purposes, which are enforced by foreign boards. In the study Berdegue', *et al.* (2005) also notes that supermarkets in Central America have moved away from the traditional method of procurement using wholesalers to the use of a) procurement agents, b) distributers that are centralised, c) chosen suppliers that are reliable and d) their own standards given to suppliers.

Urban consumers in South Africa mostly purchase their fresh fruit and vegetables from large retail chains such as Shoprite/Checkers, Pick n Pay, Massmart, Spar and Woolworths. According to Weinberger and Lumpkin, (2007), supermarkets are contributors to demand for fresh vegetables and set the bar for quality and safety standards. In this research a case study was conducted. How they operate in tracing their fruit and vegetables from the farmers to the shelf and what technology they currently use. Bosona and Gebresenbet, (2013) state that traceability in agriculture and the food supply chain is still developing and more innovations are required. The research hopes to establish the current state of traceability in South Africa as well as consider information recording, storage and

sharing, the barriers and challenges being faced in the fresh produce industry with regards to implementation of traceability and make recommendations for a way forward.

1.3 Research Question

What is the current state of traceability of South African retailers in the fresh vegetable supply chain?

1.4 Research Objectives

- To establish the current state of traceability in the supply chain
- To review the constraints the members in the supply chain face with regards to implementing traceability.
- To establish the implications of the current state and give recommendations.

1.5 Limitations of the research

The limitations were;

- The method employed in this research does not yield empirical generalisations but rather theoretical generalisations can be made.
- Participation was on a voluntary basis hence the research was limited to those who were open to interviews and observations.
- The perspective represented in the research is that of the participants in the supply chain which are farmers, pack house managers, transporters, retail managers and not those of consumers who might have a different perspective on fresh produce traceability.

- The sample size for the research was limited to one out of the nine provinces in South Africa due to financial constraints.

1.6 Assumptions

The assumptions made in this research were;

- The independent nature of the researcher would help to obtain true answers to interview questions from participants,
- The sample area used could be representative of the country as the retailers in the case study operate in all regions within the country hence the supply chain and policies do not change.

2. Literature Review

In this chapter the relevant literature with regards to traceability was studied. Areas that were looked at are traceability in the overall food supply chain, adoption of technology in agriculture, traceability information carriers, legislation, drivers, benefits and challenges of traceability, studies done in South Africa and measurement of traceability. The relevance of each area to the research is as follows:

a) Traceability in the food supply chain- this area gives an overview of world trends with regards to traceability from farm to consumers. This is essential to the research as it outlines the reasons for the introduction of traceability in the food industry.
b) Traceability information carriers- these are important as information should accompany the product at all times in the supply chain to achieve full traceability, hence the need to explore the available methods and their advantages and disadvantages.
c) Legislation- plays an important role as it compels the supply chain participants to implement traceability. Laws and regulations in the world which have influenced the implementation of traceability are explored.
d) Drivers of traceability- in this area the research explores the different issues that have driven the implementation and adoption of traceability systems with regards to the food supply chain. The research seeks to explore if the same drivers exist in the South African fresh vegetable supply chain.
e) Benefits of traceability- this area explores the benefits associated with implementing traceability. For this research it is important to know what benefits exist in implementing fully traceable systems and the effects of the current state of traceability has on realising all the benefits.
f) Challenges in traceability- the challenges that are faced by the implementation of traceability are looked at. These challenges are essential for comparison with the research supply chain

to establish if the same challenges are highlighted by participants and to act as a guide in the research.

g) Adoptions of innovations in agriculture- this area seeks to understand the trend with adoption of new ideas within the agricultural sector. As traceability can be termed new for developing countries it is important to understand the current trends. The adoption of technologies that aid with information storage and transferring to others in the supply chain is also explored as this is essential to traceability.

h) Measurement of traceability- the main objective of the research is to evaluate the current state of traceability which would require measuring it, this area provides the necessary aspects to fulfil the objective of the research.

i) Studies in South Africa- this area explores studies that have been carried out in South Africa on either traceability or the fresh vegetable supply chain. The aim is to show the gap that exists and the relevance of the current research to the country.

j) Agricultural trends in South Africa- this area focuses on the retailer trends as well as economic and agricultural production trends within the country.

k) Policies in the fresh vegetable supply chain in South Africa- the focus is on the various policies that exist and certifications that the participants in this research make use of.

All these areas gave an insight into the traceability of the food supply chain, how the current state in South Africa can be evaluated and the challenges faced by the parties involved in the supply chain. The gap that exists with regards to traceability has been explained in the motivation for the research in chapter 1 and is also explored in section 2.9. A theoretical framework was developed from the literature which was used in the evaluation of the objectives for the research and to fulfil the gap that exists.

2.1 Traceability in the food supply chain

Traceability can be defined as "*the ability to access any or all information relating to that which is under consideration, throughout its entire life cycle, by means of recorded identifications*" (Olsen and Borit, 2013). The European commission defines traceability as "*the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution*" (European Union, 2002) Regulation 178/2002.

The bovine spongiform encephalopathy (mad cow disease) outbreak in the 1990s led to the formation of the GLOBAL G.A.P (Good Agricultural Practice) in 1997 as EUREPGAP (Euro-Retailer Produce Working Group) which was a collaboration between British retailers and supermarkets to set voluntary standards for certification that would apply around the world (Souza Monteiro and Caswell, 2009) . The standards focused on product safety, welfare of staff and animals and sustainability among others. With the increase in trade, the certification has become international and more of a requirement for export around the world as more countries make use of it. Obtaining the certification ensures access to global markets. Local versions are now available which are adapted to local conditions such as China GAP, J-GAP for Japan and Thai GAP for Thailand. The availability of local versions have significantly reduced the cost of audit and inspection thus leading to the inclusion of small farmers who can form groups and afford the certification as previously the process and documentation was not suitable for them (Walsh, 2009).

The introduction of traceability to the fresh fruit supply industry is due to contamination by food borne pathogens (Florkowski, *et al*. 2009). It became a necessity after contaminated produce had to be recalled quickly and effectively to avert major outbreaks or disasters. According to Piramuthu *et al* (2013) the complexity of the food supply chain has made it more susceptible to incidents of contamination and due to dispersion, sometimes the destination of the contaminated food cannot be

established. In Belgium, consumer concerns for food safety and quality have led to the implementation of a traceability system in the beef and pork industry. The use of the traceability system hopes to quickly and effectively detect any disease, chemical or hormone presence and restore consumer confidence (Viaene and Verbeke, 1998).

Ruiz-Garcia, *et al*. (2010) describes in detail the role of precision farming in traceability. The information that it contains about the variety of seed used, fertiliser applied, pesticide or insecticide used and when harvesting is done among other tasks. It also gives the specifics of place, time and date all these tasks where performed. This information would be valuable in the food supply chain.

Xiao-hui, *et al.* (2007) indicates that the shortage of laws governing traceability in China and the lack of technology to test for food quality and safety within the supply chain, has led to the overuse of pesticides during growing of crops and the retention of hazardous amounts when harvested which have a negative effect on food safety. In 2005, a poisonous garlic accident compelled the Chinese government to issue traceability safety measures (Xiao-hui, *et al*. 2007).

When a country has no mandatory traceability standards, suppliers and firms resort to voluntary traceability by use of international standards. According to Banterle and Stranieri, (2008), the use of voluntary standards presents more advantages as opposed to mandatory ones as the former ensure better quality and safety of produce. These advantages are due to the fact that the companies that administer the voluntary standards have to maintain their reputation and hence ensure that the requirements for certification are in place always.

2.2 Traceability information carriers

Traceability systems are widely used in all industries and contain identification information of the product and links between each and every step in the supply chain. The earliest forms of traceability

used the paper and pen system. Although it is still useful for small companies and smallholder farmers, it poses problems when the supply chain has multiple links and the information in the paper cannot be accessed by all players within the supply chain. It is also a manual system which is prone to human error and loss of records or ineligible record keeping or missing information. Documents can also be electronic. They still pose a disadvantage of human error as they can easily be deleted and therefore do not give any form of security. Due to the advancement in information technology, more options are now available to effectively trace forward and trace back products within a supply chain. The traceability system is governed by the cost of its implementation and the standards it adheres to (Chrysochou *et al*, 2009).

Alphanumeric codes are a series of numbers and letters that can be placed on a product or label. The numbers do not contain any information on the product but are used as a reference to data stored elsewhere (Bechini*, et al.* 2008). Their advantage is that they are cheap to design. The disadvantages are that because of the long sequence of numbers and letters, human errors cannot be avoided. Since the reading of the codes is done manually, it requires a lot of manpower to do the work therefore it becomes costly to run and data integrity is also compromised (Regattieri, *et al*. 2007, Bosana and Gebresenbet, 2013). There are also no set standards for the codes hence individuals and companies design their own codes which are not compatible (Regattieri, *et al*. 2007).

Barcodes are more common in the supply chain as they are error free and use automatic identification technology (Regattieri, *et al*. 2007). For the barcode reader to be able to read the codes, they should be in the line of sight. Hence manpower is needed to place all codes facing the same direction to avoid errors. The barcodes are also prone to damage due to their large size which then renders them useless (Regattieri, *et al*. 2007). According to Chrysochou, *et al*. (2009) linear barcodes are cheap to implement and easy to use, however they have a limited storage capacity.

Radio frequency identification (RFID) is an automatic identification technology used in traceability in different supply chains. This form of technology makes use of a microchip and antenna that transmits wirelessly (Regattieri, *et al*. 2007).

Advantages

- Multiple products can be read at once (Kang and Lee, 2013)
- Can be used in the food industry (Kang and Lee, 2013, Bosana and Gebresenbet, 2013, Ruiz-Garcia and Lunadei, 2011)
- Can store large amounts of information (Kang and Lee, 2013, Ruiz-Garcia and Lunadei, 2011)
- Does not require direct line of sight to be read (Kang and Lee, 2013, Ruiz-Garcia and Lunadei, 2011)
- Can be read from a distance (Chrysochou, *et al*. 2009, Ruiz-Garcia and Lunadei, 2011, Kang and Lee, 2013)
- Can be updated while in use (Chrysochou, *et al*. 2009)
- Contains unique product information such as temperature throughout the supply chain (Chrysochou, *et al*. 2009)
- Offers high levels of security (Kang and Lee, 2013)

Disadvantages

- The microchip is very expensive and hence has an effect on the overall cost to the implementer, be it the farmer, retail chain or transport company (Kang and Lee, 2013, Chrysochou, *et al*. 2009, Ruiz-Garcia and Lunadei, 2011)
- The RFID tag can be affected by wet or cold environments (Chrysochou, *et al*. 2009, Roussos, 2006, Ruiz-Garcia and Lunadei, 2011)
- The wireless transmission can also be affected by metal objects (Chrysochou, *et al*. 2009, Roussos, 2006, Ruiz-Garcia and Lunadei, 2011)

- The amount of data stored on the RFID tag is difficult to manage (Ruiz-Garcia and Lunadei, 2011)
- Signal strength is also affected by the land topography in farming areas and the presence of walls and barriers in green houses and warehouses (Ruiz-Garcia and Lunadei, 2011)
- The difference in standards of bandwidth in different countries also poses as a disadvantage as different readers are required to read at differing frequencies (Ruiz-Garcia and Lunadei, 2011)
- The lack of skilled personnel is also highlighted in the study as this affects implementation in agriculture (Ruiz-Garcia and Lunadei, 2011)
- Personal privacy is compromised when tag is not removed at point of sale, as after purchase the tag remains active with the consumer hence giving off location details and other private information (Roussos, 2006).

Deoxyribonucleic acid (DNA) is used in the meat and fish industry as well as in the processing industry where many food products have been mixed together and are difficult to identify. It is also used to identify genetically modified organisms (GMO) that may be present in food. The mostly used method is the polymerase chain reaction (Miraglia, *et al*. 2004, Peano, *et al*. 2005). Galimberti, *et al*. (2013) states that DNA barcoding is sensitive, fast, reliable and cheap. These advantages can be attributed to the availability of equipped laboratories, trained personnel as well as internet accessibility which contains a lot of free data and the decreased cost of molecular analyses. The current disadvantage was the lack of representation of all species in the online databases hence until all species are identified and recorded the method is not very useful in traceability.

Other technologies available for traceability are structured database solutions, nanotechnology, nuclear techniques, edible tags and e-paper tags. Structured database solutions are cheap to obtain as they can be purchased online. They are however many available options hence in a supply chain sharing of data might prove difficult as systems are not always compatible and traceability may fail.

Information that is required by each database also varies as there is no standard framework to be adhered to. Nano sensors are used in traceability, food safety and to detect contamination (Momin, *et al*. 2013), these are devices that consist of a sensing layer and electronic data processer which can transmit the presence of a contaminant into an electrical signal. Risks of the presence of the nanoparticles in food and their safety are still to be established (Momin*, et al*. 2013). Edible tags are a form of laser technology and are still under development. The laser makes markings on the fruit or vegetable which then forms the identification or tag (Chrysochou*, et al.* 2009). E-paper tags are similar to paper based tags but use the technology that is in e-book readers and cellular phones. Nuclear techniques were used in an Italian study on traceability of garlic. Using the technique High Resolution Magic Angle Spinning-Nuclear Magnetic Resonance (HRMAS-NMR), samples were classified successfully into cultivars and the geographical region of origin was obtained. The technique proved useful in traceability for safety and fraud (Ritota, *et al*. 2012).

There are other forms of technology that aid traceability such as vehicle tracking technologies which can be used in transportation traceability in the fresh vegetable supply chain. These technologies include a) Automatic Vehicle Location (AVL) such as Global Positioning systems (GPS) and gyroscopes, b) mobile communications such as mobile radio, cellular phones, satellite c) displays on screens d) speech recognition and voice synthesis, and e) memory cards (Florence and Queree, 1993).

The advancement of technology in Japan has led to consumers being able to trace their food back to the farmer and obtain information such as where it was grown, what inputs such as chemicals were used, when it was harvested and the picture of the farmer who produced it (Hall, 2010). The consumers make use of Japanese smartphones to read 2D barcodes that are placed on the fresh fruit and vegetables.

2.3 Legislation

In this section the different laws and regulations that have influenced the implementation of traceability in specific countries and across the world are stated.

The Codex Alimentarius Commission was established in 1962 to implement a Food Standards programme for the Food and Agricultural Organisation (FAO) and the World Health Organisation both arms of the United Nations (Food and Agricultural Organisation, 1999). The Codex Alimentarius deals with product quality and safety which are standards that are important in food production and traceability ensures that these standards are always adhered to at every point in the food supply chain.

On January 4, 2011, the Food Safety Modernisation Act (FSMA) was signed into law by the president of United States. The law aims to prevent contamination rather than respond to outbreaks. This led to an implementation of a pilot project by the United States Food and Drug Administration (FDA) that hopes to enable product tracing. The project has so far recommended that all actors in the food supply chain record the same information and pass it on to enable easier product tracing in the case of an outbreak or contamination, as there is no standard that exists on the information recorded and the amount and technology to be used (Food and Drug Administration,2013).

In the United States the National Institute of Standards Technology (NIST) under the Department of Commerce issued a Policy on Metrological Traceability. In the policy NIST defines the measurement of traceability and achieving measurement results. The focus of the policy is on calibration of instruments. They provide companies with products on measurement of traceability and on assessing others about their claim of traceability (United States NIST, 2009).

Different countries have adopted differing regulations for traceability. According to Chrysochou *et al* (2009) the European Union has its own regulations that came into effect in January 2005 which govern the amount of information that can be recorded and the different categories. In the United States it

is mandatory for meat and poultry to have labels that specify country of origin (Federal Register 2008). This applies to Beef, Pork, Lamb, Chicken, Goat Meat, Perishable Agricultural Commodities, Peanuts, Pecans, Ginseng, and Macadamia Nuts. In Japan traceability has been implemented for locally produced foods which according to Hall (2010) will help in selling more local produce to consumers rather than imported produce. Japan introduced new regulations in 2002 after mad cow disease and mislabelling cases. The new regulations required an identifying ear tag for each cow and records (Popper, 2007).

France introduced the law on individual traceability for animals such as pigs and goats in 1969 and has expanded to include processed beef. The French government manages all the information within the traceability system (Choe, *et al*. 2009).

Canada had a mad cow disease outbreak in 1987 which led to new legislation that required a unique number to be given to each animal for tracing along the supply chain. According to Popper (2007) the system was made mandatory for all items in the food supply chain.

The Philippines introduced a National Standard for Fresh fruits (PNS/BAFPS31:2005). This applied to the grading and classification of mangosteen that is sold to the consumers. The Bureau of Agriculture and Fisheries Product Standards (BAFPS) had to conduct public consultations and reviews before the standards came into effect.

The Organisation for Economic Co-operation and Development (OECD) has membership of more than thirty countries and gives regulations on the standards to be adhered to for trade of fresh and frozen fruit and vegetables (OECD, 2006). In the regulations, quality control procedures and operating guidelines among other requirements are listed for implementation in the various countries. Other international organisations are also included in their discussions and implement their regulations, such as Food and Agriculture Organisation (FAO), World Health Organisation (WHO) United Nations Economic Commission for Europe, Liaison Committee for the Promotion of Tropical Fruits and Out-of-Season Vegetables imported from ACP Countries into the EU (COLEACP), European Association of

Fresh Produce Importers, Exporters, Wholesalers and Distributors, and Retailers (FreshfelEurope) (OECD, 2006).

The United Nations Economic Commission for Europe (UNECE) is an organisation that develops standards for agricultural produce and was set up in 1947 by the United Nations Economic and Social Council. They focus on ensuring quality of produce, profitability of the business and also consider the consumers. The standards are used internationally for trade within the fifty six member countries that are part of this organisation and internationally. The standards that are developed by this organisation are also implemented in the regulations of Codex Alimentarius Commission, GlobalGAP and OECD.

2.4 Drivers of Traceability

Traceability has many drivers and they differ from one supply chain to another. The food supply chain has mainly been driven to implement traceability due to contamination outbreaks that have led to some countries imposing legislation on traceability. Legislation has so far been the major driver (Food and Agricultural Organisation, 1999, Hall, 2010, Chrysochou, *et al*. 2009, Bollen, 2004, Opara and Mazaud, 2001, Schwagele, 2005, Wang and Li, 2006, Smith, *et al*. 2005, Bosona and Gebresenbet, 2013).

According to Florkowski*, et al*. (2009), Bosona and Gebresenbet, (2013), Bollen, (2009) traceability is also driven by the consumers' need for good quality and safe fresh produce. As consumer preference changes as they purchase one fruit of poor quality once and then change to a better quality one, the supplier is forced to trace where in the supply chain the quality deteriorated and implement measures so as to avoid losing customers and incurring losses. Moe, (1998), Elbers *et al*. (2001), Smith*, et al*. (2005), Bollen, (2009) and Viaene and Verbeke, (1998) also agree with the fact that safety of food is a driver of traceability as companies try to capture consumer confidence they might have lost during food scares and contamination. Quality is also of importance in the fresh food supply chain and

contributes to the implementation of traceability systems to ensure it is always upheld (Zadernowski, *et al.* 2001, Viaene and Verbeke, 1998, Wang and Li, 2006, Riden and Bollen, 2007, Galvão, *et al*. 2010, Frederiken, *et al*. 2002, du Plessis and du Rand, 2012, Pouliot and Sumner, 2008). Consumer behaviour has also contributed as more questions are asked about where their food comes from and what it contains (Opara, 2002). With the increase in health risks and the desire by most consumers to live healthy lifestyles and eat healthy food the need for traceability information is on the rise (Florkowski*, et al*. 2009, Bosona and Gebresenbet, 2013).

Sustainability is also a driver of traceability (Schmid and Connelly, 2009, Roheim and Sutinen, 2006, Olsen and Aschan, 2010). With global warming concerns and the need for greener approaches to food production, farmers have had to find ways to meet the demand for more food as population increases using sustainable methods. Good farming practices have also become a requirement in their ability to supply large retail chains and export.

The need to export fresh produce has led to a rise in organisations that certify food producers, and a requirement to obtain this certification is the ability to trace each product back to the supplier. Therefore certification drives traceability (Schmid and Connelly, 2009, Roheim and Sutinen, 2006, Frosch*, et al.* 2008, Bevilacqua, *et al*, 2009).

As companies that implement traceability obtain competitive advantage (Sant'Ana, *et al*. 2010, Smith, *et al.* 2005, Porter, 1980, Carriquiry and Babcock, 2007, Olsen and Aschan, 2010), others are encouraged to follow suit or lag behind. With satisfied consumers, increase in productivity and assurance of quality and safety as the added benefits, competitive advantage is deemed a driver of traceability (Pouliot and Sumner, 2008).

Welfare (Madec, *et al*. 2001), chain communication (Frederiksen, *et al.* 2002), bioterrorist threats (Olson, 2005, Thompson, *et al.* 2005, Thakur, *et al.* 2010), production optimisation (Ruiz-Garcia, *et al.* 2010, Bollen, 2009), guaranteed product origin, improved supply management, differentiation of

products from suppliers, monitor specific production methods (Pouliot and Sumner, 2008) are also drivers of traceability.

According to Bosona and Gebresenbet, (2013), technology is also a driver of traceability. With the increase in innovations that are suitable for use in the food supply chain and less costly, implementation is now easier and more desirable.

2.5 Benefits of Traceability

Implementation of traceability has many benefits such as consumer confidence (Ruben, *et al*. 2007, van Rijswijk*, et al*. 2008, Bechini, *et al*. 2008, Bosona and Gebresenbet, 2013). When the quality and safety standards are continually upheld consumers remain loyal to brands or specific products (Hall, 2010, Banterle and Stranieri, 2008). Consumers are also guaranteed of safety, quality and the continued uniformity of products they purchase (Clapper, 2010, Coff, *et al.* 2008, Moe, 1998, Bevilacqua, *et al*. 2009, Hatanaka, *et al*. 2005, Regattieri, *et al*. 2007, Banterle and Stranieri, 2008, van Rijswijk*, et al*. 2008, Turci, *et al*. 2010, Zhang, *et al.* 2010) giving them assurance in their retail chains. Complaints about food purchases not meeting the consumers' expectation are also reduced. The overall services offered to a customer are greatly improved (Bevilacqua, *et al*. 2009).

Karlsen, *et al*. (2013) and Bevilacqua, *et al*. (2009) state that production is optimized by the use of traceability systems. In the study of the United States livestock industry, Smith, *et al*. (2005) also agrees and states that the business becomes more sustainable by focusing on the production of animals that require less feed, are not attacked by many diseases or are more resistant and have a high growth rate. That breed is chosen above others leading to higher production and better business. By optimizing production, the costs are reduced which is an added benefit (Clapper, 2010, Thakur, *et al.* 2010, Storøy, *et al.* 2013, Hall, 2010).

By implementing traceability the company can have better coordination in its supply chain (Florence and Queree, 1993, Olsen and Aschan, 2010, Hall, 2010, Regattieri, *et al*. 2007, Banterle and Stranieri, 2008, Bosona and Gebresenbet, 2013). The chain of custody is well documented and can be traced back (Clapper, 2010, Thakur, *et al.* 2010, Bevilacqua, *et al*. 2009, Storøy, *et al.* 2013) and issues within the supply chain can be resolved. Foods labelled as regional or imported can be authenticated by tracing back the supply chain. Efficient recalls in the case of outbreaks can also be made and losses can be kept to a minimum (Moe, 1998, Hall, 2010, Banterle and Stranieri, 2008). According to Bevilacqua, *et al*. (2009), Regattieri, *et al*. (2007), Olsen and Borit, (2013) companies in the food industry that integrate their supply chain and the traceability system reap more benefits by becoming more competitive.

The Agricultural industry is vulnerable but very critical to the growth of a country and economy. Attacks on food have a negative impact on economy and consumer confidence. In the case of a bioterrorist threat, biosecurity of the livestock population or the crops and fields is of great importance (Smith, *et al.* 2005, Thakur, *et al.* 2010). Having concentrated populations in one area is a risk and programs should be in place to respond to security threats (Clapper, 2010). According to Storøy, *et al.* (2013), food security is a benefit of traceability.

Traceability enables the verification of origin (Hatanaka, *et al*. 2005, Chrysochou, *et al.* 2009, Turci, *et al.* 2010) and ownership of products which helps deter theft. In the livestock industry it has become mandatory as a condition of sale or for movement from one area to another. This also aids in misrepresentation issues with meat and livestock (Smith, *et al.* 2005) and information accuracy (Florence and Queree, 1993, Olsen and Aschan, 2010). In the fresh fruit and vegetable industry information on origin is also a benefit as it assists in verification of claims in the production process such as organic (Clapper, 2010, Thakur, *et al.* 2010, Vermeir and Verbeke, 2006, Hamprecht, *et al*. 2005, Chrysochou, *et al.* 2009).

With efficient traceability systems, companies become compliant to regulations (Smith, *et al*. 2005, Thakur, *et al.* 2010, Moe, 1998, Storøy, *et al.* 2013, Resende-Filho and Buhr, 2008, Mgonja, *et al*. 2013, Banterle and Stranieri, 2008) such as country of origin labelling (COOL) which is a mandatory in the United States for all animal products and listed fruits and vegetables and has become mandatory in South Africa for imported fresh food produce.

Companies benefit from traceability by being able to contain, eradicate and monitor diseases. The diseases can be from locally produced food or from imported ones (Smith, *et al*. 2005). With sufficient labelling and provision of information in the supply chain the source can be traced back, faults corrected and closely monitored for future purposes.

Other benefits of traceability include ability to measure carbon footprint and contribute to industry sustainability, management of a crisis in unusual conditions, protection of brand name and being a competitive company or market leader, minimise product recalls (Smith, *et al*. 2005, Clapper, 2010, Hall, 2010, Karlsen, *et al*. 2013, Bosona and Gebresenbet, 2013), accurate profit and cost measurement (Florence and Queree, 1993, Banterle and Stranieri, 2008, Olsen and Borit, 2013), and reduce postharvest losses (Hatanaka, *et al*. 2005).

2.6 Challenges in Traceability

According to Holt, *et al*. (2007) the policies for privacy, data security and a company's will to retain autonomy hinder the sharing of information with others in the supply chain. Without adequate information being shared between players in the supply chain, traceability is not possible or has insufficient information and hence will be unsuccessful (Florkowski, *et al*. 2009, Storøy, *et al.* 2013). Due to the existence of competitive advantage, selective disclosure is often exercised by firms resulting in little or less useful information only passed on to others (Porter, 1980, Benton and Maloni, 2004) hence traceability is compromised. A farmer will only share information if there is a benefit to

the business such as being awarded the contract or long term partnerships (Souza Monteiro and Caswell, 2009). In the case of contamination or an outbreak, the lack of information hinders timely recalls and containment of the situation (Piramuthu*, et al*. 2013).

Implementation of traceability will also affect employees' privacy as it can be compromised, that is transporters and suppliers' individual whereabouts are to be tracked as the transport the fresh produce within the supply chain (Popper, 2007). As most farm workers may also be immigrants, information gathered about their whereabouts during traceability may be used against them (Popper 2007). Popper, (2007) also highlights the issue that consumers may value their privacy over traceability as their purchases are recorded and this may cause a challenge in the implementation of traceability. Smith, *et al*. (2005), Pouliot and Sumner, (2008), agree that in the United States livestock supply chain, farmers are faced with the problem that information that has been stored for traceability, may lead to them being fined or penalised for producing poor quality products and not being compliant and are hence hesitant about its implementation. Bosona and Gebresenbet, (2013) state that the effects of implementing traceability can lead to high costs when an outbreak occurs and recalls are conducted. This leads to reputations being tarnished and in many cases companies going out of business due to liability costs and claims from those that were affected by the outbreak and the recall.

Popper (2007) also raises the issue that introduction of traceability may lead to increase in labour costs as the new technology will require data entry and increase in manpower, and the major drawback to its implementation would be covering of this unplanned cost. In most cases the costs are absorbed by those in fewer numbers or smaller organisations along the supply chain. In the analysis of cattle farming by Resende-Filho and Buhr (2008), they noted that market inefficiencies occurred as quality assurance could not be verified as you moved down the supply chain, and this led to cost that would be absorbed by those downstream. In the fresh fruit and vegetable supply chain the cost would be absorbed by the farmers or the subcontractors and not the large retail chains (Hatanaka, *et al.* 2005). The data will need to be stored for longer periods of time as the produce moves along the

supply chain which will also add increase to the cost (Schwagele, 2005). The success of traceability systems depends on availability of funding initiatives by government to assist small farmers and cooperatives (Zhang, *et al.* 2010) to purchase the required technology and train their staff.

The fresh food supply chain also presents a challenge to traceability as the food is fresh and the time is limited for all the information to be registered, processed and stored before being forwarded to other players in the supply chain (Engelseth, 2009). The shelf life is measured as the time it takes to lose quality attributes such as nutritional value, texture, colour, freshness, firmness and aroma (Nicola and Fontana 2014). As deterioration is variable and leafy vegetables deteriorate faster than citrus fruit (Florkowski, *et al*. 2009) the implementation of traceability can be challenged in other fresh fruit and vegetables.

2.7 Adoption of Innovations in Agriculture

According to Dong and Saha, (1998), firms in the agricultural industry are reluctant to adopt new technologies and have employed a waiting attitude. This is due to the lack of information when new technologies avail themselves on the market and a possibility of better versions being produced after a short while. Burton, *et al*. (2003), Tey and Brindal, (2012) and Genius, *et al.* (2006) highlight factors that influence the adoption of technology as agriculture policies, consumer perspectives on health, lifestyle of farmer and consumers, availability of information on the technology, availability of educational materials and courses beforehand, effects on technology on sustainability and the economic benefits.

In a study on the adoption of fallow systems, Honlonkou, (2004) states that adoption is influenced by, ownership and the financial status of farmer. The degree of adoption also depends on the current state of the farm such as the degradation level or the decrease in output. In conclusion, it is noted that sharing of information among those making use of the technology and those that are not, would

benefit adoption as well as offering incentives with the purchase of the technology. Policy alone without extension services will not encourage the adoption of agriculture technology. Knowler and Bradshaw, (2007) in their study also agree with Honlonkou, (2004), Burton, *et al*. (2003), Genius *et al.* (2006), Tey and Brindal, (2012), about factors influencing adoption, and in their synthesis also highlight other factors such as farmers' age, education level, gender and farm size.

The adoption of wireless sensors has been low and in the study by Wang, *et al.* (2006) the reasons for not adopting included, lack of set standards, large quantities of data generated are difficult to manage, high cost, unreliable electricity supply, reliability has not be established and lack of skilled personnel. Chrysochou, *et al.* (2009) states that the adoption of new technologies in the agriculture food supply chain is hindered by the availability of so many choices with little information about their use and benefits, hence the lack of adoption.

According to Souza Monteiro and Caswell, (2009), few studies exist on the adoption of traceability in food supply chains. The few that exist focus on the meat industry and not the fresh fruit and vegetables. In a study of the adoption of traceability systems in Taiwan, Liao, *et al*. (2011) concludes that the adoption rate was low as farmers did not participate in the initiative. This could be attributed to low levels of communication with the government about the program and lack of extension services to educate farmers on the benefits of implementing a traceability system. To ensure success of the traceability system, government should fund the training sessions to improve farmer awareness which encourages adoption (Liao, *et al.* 2011). According to a study by Zhang, *et al* (2010), the adoption of a traceability system depends on management and not technology. Bosona and Gebresenbet, (2013) in their review state that barriers that exist in the adoption and implementation of traceability include limited resources, limited information for an effective traceability system, the lack of standards, lack of trained staff and limited knowledge of the benefits of a traceability system. The lack of standards in the information recording and exchange for traceability poses a major problem for effective

traceability to be implemented (Storøy, *et al.* 2013). Some suppliers pass on little or poor quality information that is not sufficient for traceability.

2.8 Measurement of traceability

One study was found which looked at the measurement of traceability in a supply chain. According to Opara (2002), six important elements exist and when put together give an evaluation of an agricultural supply chain traceability system. These elements are: 1) Product traceability - this gives the physical location of the product at any given time in the supply chain, 2) Process traceability – this gives the sequence of activities that have occurred from growth to postharvest on the produce, 3) Genetic traceability – this gives the genetic makeup of the produce, 4) Inputs traceability – this gives the source of inputs such as fertiliser, chemicals and water, 5) Disease and pest traceability – this traces the different pests and bacteria that could contaminate the produce, 6) Measurement traceability – this is the calibration of instruments used for measurement using set standards.

2.9 Studies in South Africa

Traceability in Karoo lamb was studied by Du Plessis and Du Rand (2012) with focus on consumer perceptions. Attributes that were shown to have a greater influence on consumer decisions to purchase the Karoo lamb were safety, quality, traceability, origin and price. Traceability was deemed the driver for consumer purchase as the consumer preferred lamb that could be traced back to its birth farm despite the price.

Studies in South Africa have focused on exports in the agriculture industry such as Mather (2005), Soontiens (2002), Ntombela and Kleynhans, (2011). The study by Mather (2005) focused on small to medium enterprises in the agro processing sector of South Africa. It was established in the research that these small processers do not supply the large retailers due to the large volume required, the cost of infrastructure set out by retailers and the stringent standards they have to adhere to for quality and safety of produce.

Darroch (2001) studied the agribusiness supply chains in the country and found that to remain competitive the firms faced challenges such as managing the drivers of change and better supply chain management. Bediako and Debrah, (2007) studied the out grower scheme for Pick 'n Pay and emerging farmers in the Eastern Cape. Madevu (2006) performed a study on fresh fruit and vegetables in the Tshwane area. The study focused on the informal retailers such as hawkers and green grocers and the large retailers which are supermarkets and specialty chain stores and how both have survived or managed to co-exist.

Currently there are no studies that have focused on traceability in the fresh vegetable supply chain within South Africa or looked at the supermarket supply chain and their complexity.

2.10 Agricultural trends in South Africa

In this section, an overview of the retail industry is given, then agriculture production and economic trends are explored.

South Africa has five major retail chains which are Shoprite/Checkers, Spar, Pick n pay, Massmart and Woolworths. In a study of the top 250 global retailers in 2010, the results for the five major retailers are shown in Table 1 (Deloitte Touche Tohmatsu Limited (DTTL), 2012).

Table 1. Study of the top 250 global retailer 2010

Number	Retailer	% Growth rate 2005-2010
92	Shoprite Holdings	16.7
125	Massmart	12.1
133	Pick n pay	8.2
179	Spar Group Limited	20.7
222	Woolworths Holdings	12.4

For the 2012 financial year, Spar South Africa increased its retail turnover by 11.5 per cent to R53.7 billion (The Spar group Limited, 2012), Woolworths retail which comprises of food, general merchandise and clothing grew by 11.6 percent with food sales up 11.9 percent (Woolworths Holding Limited, 2012), Pick n Pay retail had a turnover growth of 8.1 percent in 2012 and 7.1 percent in 2013 (Pick n Pay, 2013), for Massmart sales increased by 7.7 percent for twenty six weeks ending December 2012 (Massmart, 2013), and Shoprite realised a 12.1 percent increase in sales for the year end June 2013 (Shoprite Holdings, 2013). This notable growth in the retail industry due to sales of general merchandise and food is of relevant importance to growth in the economy of a country.

Mather, (2005) states that, the supermarkets that belong to the large retail chains in South Africa account for sixty percent of the food sales. According to Statistics South Africa, the Agriculture, fisheries and forestry sector increased in performance by 6.7 per cent to Gross Domestic Product (GDP) in 2013 compared to the same period in 2012, the industry's expansion was notable as it contributed up to R33 million in the second quarter of 2013 (GDP, 2013).

The production of vegetables is concentrated to specific areas for certain crops within the country. Green peas are mainly grown in George and Vaalharts, green beans in Marble Hall, Tzaneen and Kaapmuiden, onions mainly in Pretoria, Brits and Caledon and asparagus mainly in Krugersdorp and Ficksburg (Department of Agriculture, Forestry and Fisheries, 2014).

Direct sales which amount to 43 percent are made to supermarkets and retail stores in the distribution of vegetables pie chart shown in figure 1. This also includes consumption by the farmers. The greatest distribution occurs through fresh produce markets which account for 46 percent. The fresh produce markets are municipal run and currently there are nineteen markets within South Africa.

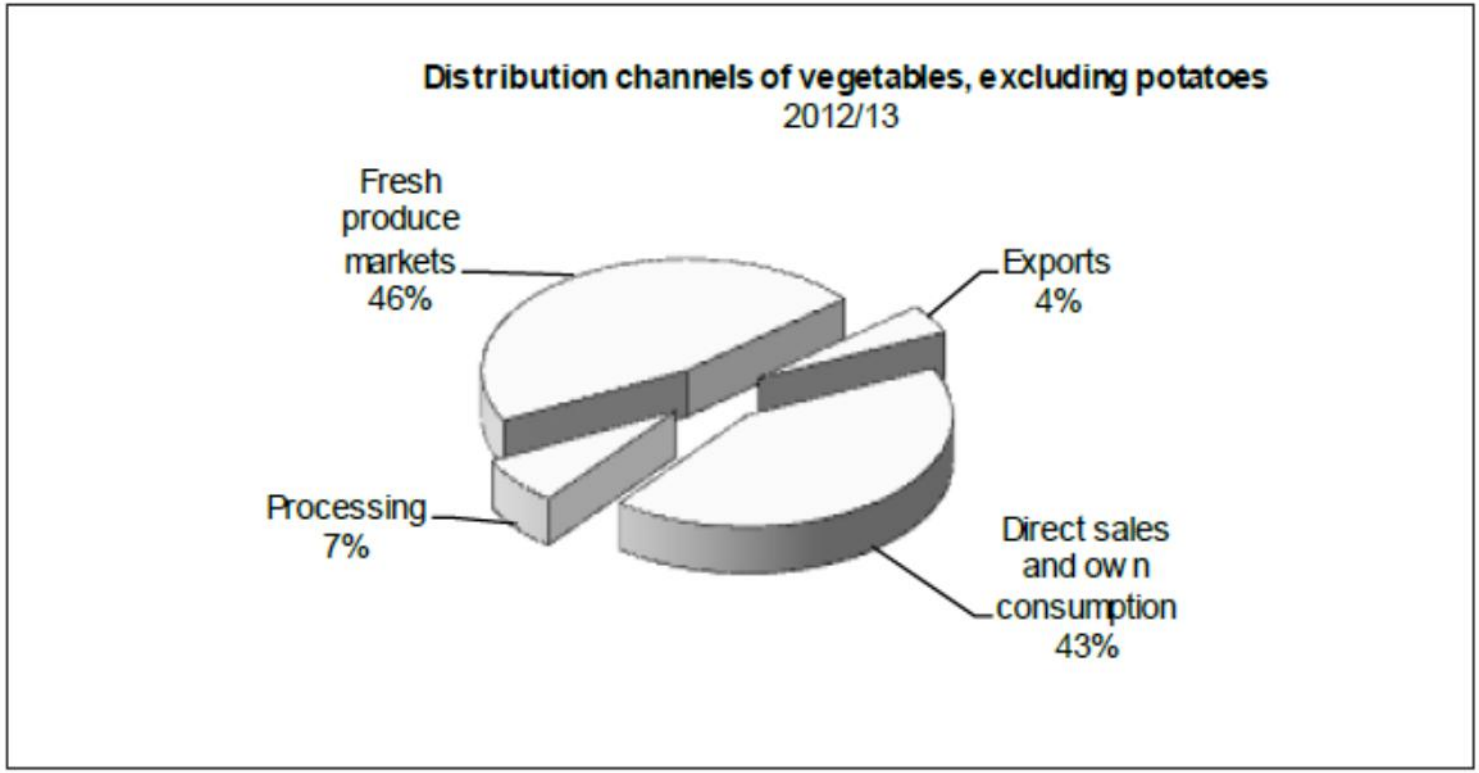

Figure 1. Distribution channels of vegetables (DAFF, 2014)

The graph in Figure 2 shows vegetable production in South Africa from 2006 to 2010. The decrease in production in 2009 could be attributed to weather conditions. The health benefits of vegetables are stressed in the Crop and Markets Economic review hence the need to increase the consumption (Department of Agriculture, Forestry and fisheries, 2011). Generally it can be noted that vegetable production has been on a steady increase.

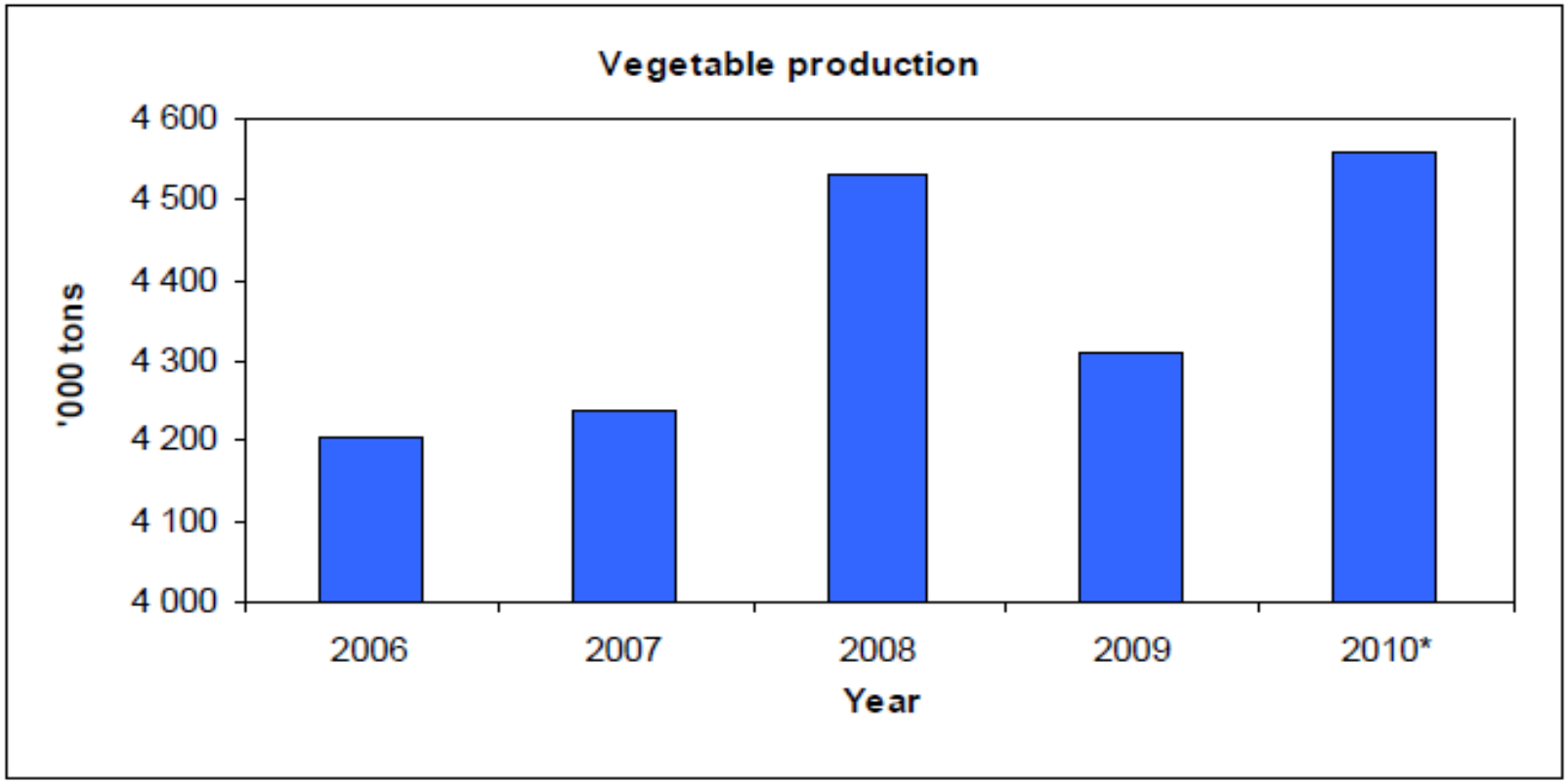

Figure 2. Vegetable Production (DAFF).

According to the South African Department of Agriculture, the gross value of agricultural production for the year 2012/13 is estimated at one hundred and eighty billion rands which is an increase of 10.2 percent from the previous year. The horticultural industry, which includes fruits and vegetables contributed 25.0 percent to the gross value (Department of Agriculture, Forestry and Fisheries, 2014). Agriculture as a sector contributed 2.6 percent to the total value added to the economy for the year ending December 2012 as shown in table 2. The trends in the gross value contribution to the economy are shown in figure 3 and 4.

Table 2. Contribution of agriculture to total value added (DAFF)

Year	Total value added R'million	Contribution of agriculture to value added R'million	Contribution of agriculture as % of total value added %
2005	1 401 067	30 213	2,2
2006	1 572 319	37 475	2,4
2007	1 792 075	45 152	2,5
2008	2 027 751	50 263	2,5
2009	2 178 321	52 903	2,4
2010	2 407 264	48 909	2,0
2011	2 621 379	49 799	1,9
2012*	2 835 087	72 731	2,6

*Note: Figures are for agriculture, forestry and fisheries

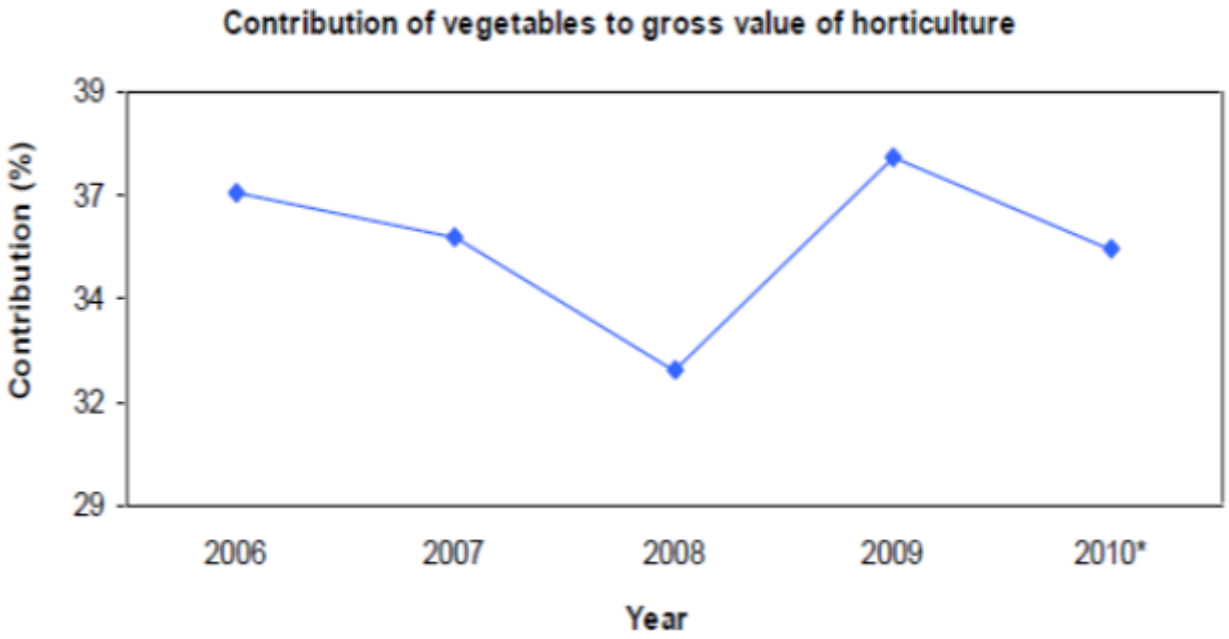

Figure 3. Contribution of vegetables to gross value of horticulture (DAFF).

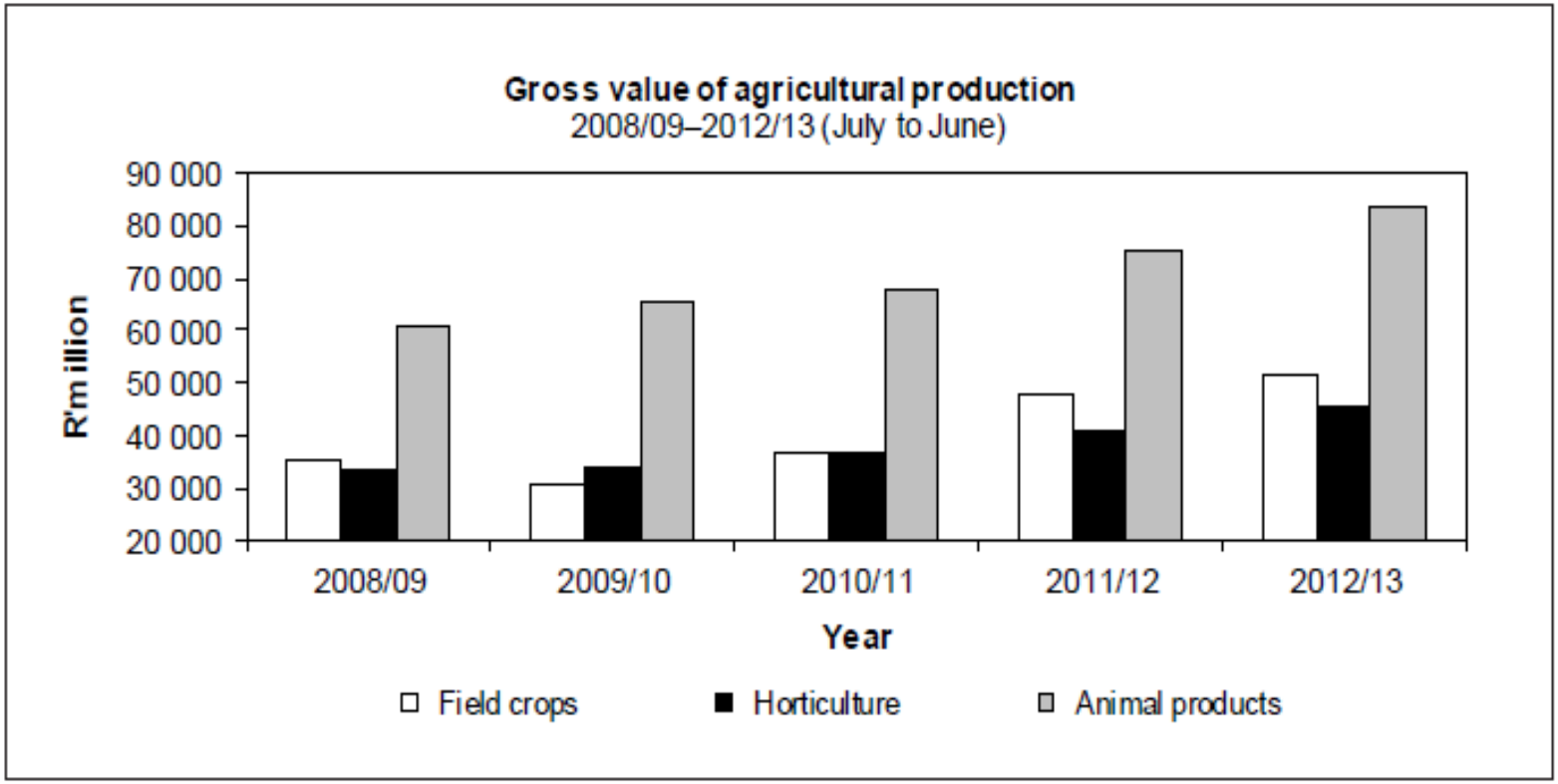

Figure 4. Gross value of agricultural production (DAFF).

2.11 Policies in the fresh vegetable supply chain in South Africa

Firstly a detailed explanation of policies that govern the sale of fresh produce is explained which includes Acts from the South African Department of Agriculture, HACCP, FSI, as well as Global GAP policies.

Product Control for Agriculture (PROKON) was established in 1985 after the South African Department of Agriculture removed quality and safety testing at fresh produce markets as they deemed them not a priority. It is a self-funded non-profit organisation that performs quality assurance and grading for potatoes that are sold on the fresh produce markets. This ensures correct pricing and quality produce for consumers. The organisation also performs quality assurance on other fresh produce such as fresh vegetables and fruits when requested. (PROKON, 2012)

The Agricultural Product Standards Act of 1990 (APS) sets out regulations for fresh produce grading, quality and packaging requirements for farmers to be able to sell their produce. The grading involves classification due to size and appearance in colour. The Act in Section 15 applies to fresh produce to be sold within the country. Imported fresh vegetables that adhere to Codex, UNECE or OECD are exempted. Quality checks are performed on all produce. For potatoes they are cut and the residue levels tested. Other fresh vegetables are checked for phytosanitary organisms that are harmful to humans. Residue tests are performed on random samples, only export produce is tested regularly by the South African Agricultural Food, Quarantine and Inspection Services (SAAFQIS), which has laboratories in Pretoria and Stellenbosch under the Standard Operating Procedures (SOP) of the South African Department of Agriculture (SOP, 2006). For packaging requirements from APS, all produce for sale should be packed in clean, new containers that are strong enough to handle their weight, do not impart any taste or odour and do not bulge or dent during handling and transportation and can be cleaned and disinfected before re-use. The containers have to be clearly marked with the name of the

producer or packer, the producer code, the class or size, the type of fresh vegetable, the cultivar, the date and the country of origin. No mixing of size or quality and cultivars is allowed for produce that is displayed loosely. Sampling is done on two percent of the containers of the fresh produce in a consignment which are visually checked by an inspector. The act provides more specific quality attributes and their classification and the list of quality assurance properties such as sun damage, checking for amount of pips and jelly in tomatoes, which are to be considered for the different fresh vegetables. This provides a detailed information list for the producer and the inspector. Failure to comply may lead to a fine or imprisonment. (Government Gazette, 2009). This policy is mainly implemented in the fresh produce market.

A list of country specific maximum residue limits exists on the Department of Agriculture website. It lists the amount permitted as residue for all fresh vegetables. The MRLs are set by the Department of Health in the Foodstuffs, cosmetics and disinfectant act, 1972 (ACT NO. 54 OF 1972), (Department of Health, 2006).

Hazard analysis and critical control points (HACCP)

Hazard analysis and critical control points (HACCP) is a system to ensure food safety and quality during the production process. HACCP began with National Aeronautics and Space Administration (NASA) ensuring food safety during its space missions in the 1960s. It is now used internationally as a risk assessment tool to manage food safety. It is mainly based on the safety of the food produced and not the quality. It has now been adapted for use in other production industries such as cosmetics. HACCP consists of seven principles which are 1) Conduct a hazard analysis, 2) Determine the critical control points, 3) Establish critical limits, 4) Establish critical control point monitoring requirements, 5) Establish corrective actions, 6) Establish procedures for ensuring the HACCP system is working as intended, 7) Establish record keeping procedures (Department of Health, 2003). Implementation of

HACCP has many benefits including ensuring food safety, fewer customer complaints, traceability, competitive advantage and effective response to contamination. The certification is provided by independent bodies.

Food Safety Initiative (FSI)

This is a system administered by the Consumer Goods Council of South Africa and focuses on food safety, nutrition and regulations related to food. It has established the first food safety audit system named Global Food Safety Initiative (GFSI) which is implemented by some packing facilities in this research. GFSI offer certification and audits in food safety (Consumer Goods Council, 2013).

Global GAP

Global GAP, as introduced in the literature review, provides a voluntary standard and certification for farmers. When it was established in 1997, it provided harmonised standards for European farmers who now only required one audit and adhered to all the safety and quality regulations regarding food they produced. The certification is issued by independent certification bodies around the world to farmers who have successfully implemented the Global GAP standards. These independent certification bodies have to firstly obtain accreditation from Global GAP so as to issue valid certifications. Certification is available for individuals, companies or groups that implement a quality management system. The Global GAP standards are crop specific and for fruit and vegetables they cover pre-harvest and postharvest activities such as soil management and plant protection.

The process of obtaining certification starts with the farmer choosing a certification body within their country which then becomes responsible for the certification and collection of fees. The produce safety certification covers fruit and vegetables that can be consumed fresh, cooked or processed by

humans and does not cover vegetables used only for aromatic purposes or medicinal use (Global GAP, 2013b). For the farmer to obtain certification, traceability should be in place and relevant documents should be kept. The Global GAP standards emphasise traceability on the farms and this is from receipt, handling, storage and dispatch of the produce. In the case of microbial contamination or exceeding maximum residue limits, the farmer is awarded time to rectify the problem and all documents and testing results pertaining to that particular crop are required. Audits are performed annually by the inspectors from the independent certification bodies which cover all processes on the farms and unannounced visits are also performed on ten per cent of their certified producers annually. A producer is obliged to perform a self-assessment yearly using the checklist provided by Global GAP so as to maintain the standards that are set out. The checklist sets out critical points on the farm that should be checked for conformance during production so as to obtain and keep certification. In the case of non-conformance that poses a serious threat to the safety of a consumer or environment, the producer is suspended immediately for the product that did not conform to the standards. For a minor non-conformance the issue has to be resolved within twenty eight days.

For risk analysis of microbial contamination, areas that are assessed are farm area, water supply, soil, animals, personal hygiene, equipment and containers, temporary storage areas and transportation as each can lead to produce contamination by bacteria or pathogens (Global GAP, 2013a).

The legislative environment is complex and duplicated, as a number of policies and certifications exist. This leads to repetition of processes such as maximum residue testing, as it is a requirement in all policies and certifications. The policies outlined in this section are the ones used by the case studies in this research.

2.12 Summary

From the literature review above it can be concluded that a number of options exist in the case of traceability information carriers that can be used within the vegetable industry that are affordable and efficient. The existence of traceability in other areas of the food supply chain can be used as a reference in implementation of traceability systems that are specific to the vegetable industry. Although challenges have been noted in the implementation of traceability many focus on the rights of individuals and the costs. Some of the challenges have been shown to contribute to low adoption of technologies such as lack of education and training. These challenges can be addressed with training and extension services as well as human rights consideration. The benefits that have been presented are numerous and need to be considered in the decision for adoption of traceability in the fresh vegetable industry.

The literature review also points out some important aspects in the implementation and evaluation of traceability in the food supply chain. From section 2.4 the drivers of traceability such as certification, legislation, quality and safety are very important and hence have been developed into the theoretical framework. The accuracy and consistency of information recorded and stored also plays a major role in the supply chain as it contributes to traceability being effective or non-existent as explained in section 2.6 in challenges in traceability. The availability of many options for information carriers as explained in section 2.2, led to the consideration of product packaging and processes and the use of any of these methods in the fresh vegetable industry. The adoption of technologies and need for sustainability in agriculture as a driver of traceability are important and are considered as part of the theoretical framework as buyer supplier relationships which influence traceability adoption and implementation. The literature review has led to five supply chain enablers being identified as essential components to aid in the evaluation of traceability in the fresh produce supply chain which are information management, product management, quality assurance, buyer-supplier relationships,

certification and compliance. The constraints faced in the fresh vegetable industry due to implementation of traceability are also to be considered important, as they affect the five supply chain enablers and need to be addressed.

3. Methodology

The research followed a qualitative approach and is descriptive so as to portray accurately the characteristics of the subject under investigation which is traceability in the fresh vegetable supply chain. The aspect of being descriptive aids in minimising bias and maximising reliability. This is achieved by obtaining the maximum amount of information and realising opportunities for considering different aspects to a problem (Pope, *et al.* 2000). Four criteria had to be satisfied by the research, a) all the data collected had to be credible to ensure internal validity, b) an ability to confirm had to be present to ensure objectivity, c) all information would need to be dependable to ensure reliability and d) transferable from one research case to another to ensure external validity (Shenton, 2004).

The research was carried out in the Gauteng province of South Africa. Cluster or area sampling was implemented due to geographical division (Pope, *et al.* 2000), and this type of sampling reduced cost of the overall research although it presented the disadvantage of being less precise than random sampling. The area sampling method was chosen as it awarded the researcher the opportunity to visit the suppliers, tour their premises and conduct face to face interviews on a limited budget.

A case study approach was implemented as a research strategy (Hartley, 2004). This method was chosen as it provides a detailed analysis of the theoretical issues and the processes that are involved within the area of study (Hartley, 2004, Yin, 2009). It allowed an in depth analysis of the supply chain under study and would fulfil the objectives of the study (Yin, 2012). The case study approach also enabled the researcher to give an overview of the status of traceability in the country as the retailers operate throughout South Africa. The flexibility of the case study strategy made it more suitable an approach as it can be applied to emerging theories during the course of the research (Hartley, 2004). To obtain participants, the five major retailers in South Africa that sell fresh vegetables to consumers were approached to willingly participate in the research. A brief outline of what the research was

about and the objectives and details of information required were sent to each retailer for consideration. Only three retailers responded favourably and showed interest in the study and were open to interviews with their suppliers. The other two retailers did not respond to the request to participate.

For data collection, interviews and observations were conducted (Ritchie and Spencer, 2002). This method was chosen for collecting data because it met the objectives and provided the degree of accuracy desired by enabling triangulation to ensure reliability and validity of data collected from participants (Shenton, 2004). Firstly, available literature on traceability was reviewed and a theoretical framework was established. The theoretical framework was developed to make sense of the data gathered from the case studies (Hartley, 2004). The scope of the framework was to address all objectives that would be covered by the research. Questions were developed, which focused on issues raised in the literature (Hartley, 2004). The questions were obtained from the theoretical framework focus areas under each theme, which would also address the objectives and provide sufficient information for the current state of traceability to be evaluated. Initially open ended questions were designed (Hill, *et al.* 2005). The questions were broad and were used only as guidelines in the interviews to allow the participant to explain in detail their responses. More questions were formulated as the interview progressed, these were guided by the responses from participants. Observations were made while touring the farms or facilities and distribution centres and during the interview to obtain information relevant to the research.

Firstly, the retail chain managers were interviewed and the company websites explored to obtain an overview of the supply chain and the workings of the distribution centres. With this overview groups could now be set up within the supply chain with relevance to the role they play. Due to the differences in the supply chain, questions had to be rearranged to suit the specific supplier to be interviewed as some suppliers took on more than one group due to vertical integration. Vertical integration is when a company expands its business into areas that are at different points on the same production path

such as owning its suppliers or distributors, in this case the farms have their own packing facilities and distribution vehicles. The different groups were: farmers, retail managers, quality assurance managers, market management and packing facility managers.

For this research three farms, five packing facilities, fresh produce market, three retailer representatives and distribution centres were visited and interviewed. Due to the participants who responded, the scope was narrowed to focus only on fresh vegetables as no fruit suppliers were interviewed and as the fruit industry is regulated due to exports, a conscious decision was also made to only focus on fresh vegetables. As stated earlier, the farms had packing facilities on site and this was noted as vertical integration as they now do not have to transport their produce for long distances to be packaged by someone else. After packaging their produce they deliver to the distribution centre or directly to the retailer. The facilities range from high care to medium and low care depending on the vegetables packaged and the processes involved. Those who do not wash and cut are deemed the low care facilities. The medium care may perform washing only to remove the soil but further washing before use of vegetables is required. Those that cut up and sell ready to eat vegetables that do not require washing after purchase operate the high care facilities.

Ethical considerations were also implemented during the interviewing stages and throughout the research. The three retailers who responded favourably to the call for participation became the participants in the case study. The retailers also contacted their suppliers who were interested in the research and available for interviews within the geographical region and these were also considered participants. Permission was obtained from the participating retailers before any of the interviews began.

All participants were informed about the research beforehand from the retailer and had been given an option to choose whether to participate or not to ensure credibility (Shenton, 2004). Contact was then established to set a time and date for the interview with the retailer always involved in the process. For every interview conducted, the participant was informed that the interview was going to

be recorded and given the opportunity to object if they were not comfortable. It was also explained to each participant that no names would be included in the final research report. Finally, all recordings made will not be passed on to a third party but will be kept in a personal collection.

The data was analysed using gap analysis to establish the current state of traceability. Gap analysis is used to identify the gap between the current situation and the future state (Mind Tools, 2013). For this research the ideal state of traceability is the desired future state. The analysis was done in three steps. Firstly the future or ideal state was identified from literature. The second step was to analyse the current situation. Finally ways to bridge the gap between the ideal state and the current state were identified (Mind Tools, 2013). The data that was analysed using the gap analysis method was the five enablers of the supply chain in the theoretical framework that would be used to evaluate the state of traceability.

The data was also analysed using content analysis to obtain the constraints faced by the participants in the supply chain which is a reliable approach for data handling (Roberts, *et al.* 2006). Qualitative content analysis is defined by Hsieh and Shannon (2005) as "*a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns*". A directed approach was used. This is an analysis which starts with a theory and is used as a guide to analyse the data (Hsieh and Shannon, 2005). The goal for the directed approach is to validate the theoretical framework and this was done by firstly, identifying the key concepts in theory in the literature review process and secondly, determining operational definitions for each category in which the categories also were developed from the literature. The unit for analysis was chosen as the themes (Yin, 2009) from the theoretical framework. The process mapped out by Hsieh and Shannon (2005) was implemented which involved interviews containing open ended questions and targeted questions about predetermined categories. Data is coded using the predetermined categories from the theoretical framework and data that cannot be coded is analysed

to determine if a new category should be introduced. The interview recordings were first transcribed and then analysed. The presentation of the analysis adapted from Gill *et al*. (2008), is in section 6.6.

This method produces results that either are for or against a theory and this was the desired result for this research. It does however have its limitations in that the researcher already has a strong bias towards the data due to being informed from literature (Hsieh and Shannon, 2005). The results obtained from this analysis were tabulated in the analysis section 6.6.

4. Theoretical framework

The themes that were considered in this research for the evaluation of the supply chain, were obtained from the literature review and were outlined in the summary in section 2.12, are explained in this chapter. The theoretical framework consists of three main components which are, evaluation of traceability, the five supply chain enablers and the constraints in traceability. To evaluate traceability six aspects have to be implemented. Information required to satisfy the six aspects is obtained from exploration of the five supply chain enablers. When the aspects are not fully implemented constraints or challenges are noted. When the constraints have been addressed and the six aspects fully implemented a fully traceable supply chain can exist. Figure 5 shows the link between the three main components in the theoretical framework.

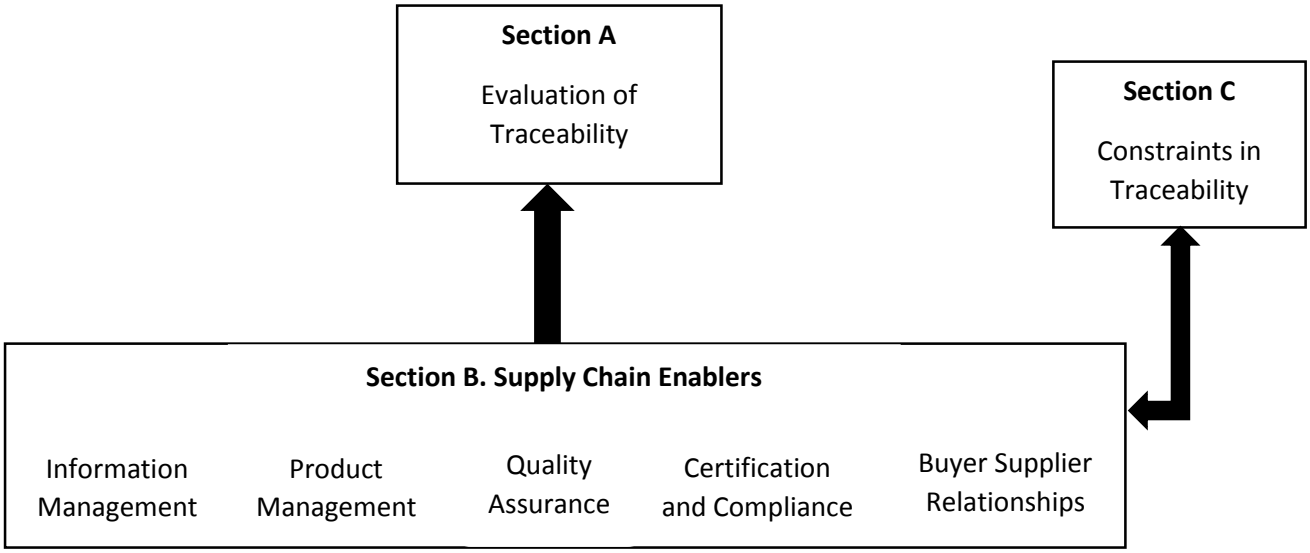

Figure 5. Theoretical Framework

Section A

In this section, the six aspects to evaluate the state of traceability are explained.

4.1 Evaluation of traceability

To evaluate the results after analysis a set of guidelines had to be established so the level of traceability could be determined. These guidelines are established from the literature and the theoretical framework.

To measure traceability the six aspects stated by Opara (2002) and described in section 3.8 of the literature review are implemented. For this research for the supply chain to be deemed traceable all six aspects had to be fully implemented. The information required to fulfil each aspect is obtained from the five supply chain enablers as follows:

1) Product traceability – the physical location of the fresh produce at any stage in the supply chain had to be known at all times.
2) Process traceability – the sequence of activities from growth to post harvest that affect the produce such as chemical, mechanical, atmospheric and environmental factors. Tests for contaminates have to be performed such as microbial and maximum residue tests. The cold chain has to be monitored throughout the supply chain.
3) Genetic traceability – the source and supplier of the seed and the variety have to be known.
4) Inputs traceability – the type and source of inputs such as fertilisers, irrigation water, chemical sprays and chemicals for washing and preservation of the end product have to be known. Incudes the tests performed on the water and maximum residue limit tests on all the produce.
5) Disease and pest traceability – tests have to be performed to establish if the disease and pests that may contaminate the food exist on the produce. These tests include microbial tests on the fresh produce.

6) Measurement traceability – the instruments used to measure the produce in the supply chain should be calibrated making use of a standard as a reference which is certified.

Three levels were established to evaluate traceability with reference to the six aspects to be fulfilled in the measurement of traceability.

Level 1 – none - was given to a supply chain which had no participants implementing the aspect.

Level 2 – partial - this was awarded to the supply chain with some participants having that aspect under question in place.

Level 3 – full - this would require all participants in the supply chain to have fulfilled the traceability aspect.

Section B

Supply Chain Enablers

In this section, the five supply chain enablers are explained including the relevant literature to show the importance of each enabler to traceability. The focus areas for each supply chain enabler are outlined and these are used to construct the interview questions in Appendix 1, and evaluate the results obtained.

4.2 Information Management

According to Florkowski, *et al*. (2009), Feldman and Müller (2003), Mentzer, *et al.* (2000), Holmberg, (2000), Monczka, *et al*. (1998), Storøy, *et al.* (2013), Kirezieva, *et al.* (2013), Piramuthu, *et al.* (2013), the exchange and quality of information is important in implementing an effective traceability system and managing a supply chain. Hu, *et al.* (2013) states that information such as soil characteristics, farmer information and seed information are essential to traceability. According to Storøy, *et al.*

(2013) repetition of collecting information occurs when one passes on data that is not useful and measurements have to be retaken leading to wastage of resources. Porter (1980) states that to retain competitive advantage firms will release poor quality information due to selective disclosure, to which Berry, *et al.* (1994) adds that firms supplying little information for either competitive reasons or otherwise affect the efficiency of the supply chain. To effectively implement traceability the different players in the supply chain should be willing to share the information they gather using the technology they have made use of (Ruiz-Garcia and Lunadei, 2011). In this research the focus was on:

- the amount of information they record and pass on to others
- the quality of the information i.e. is it accurate, useful and consistent
- the technology they use for information gathering and storage

4.3 Product Management

Product management is important as it determines the way in which information will be passed on and recorded. Management of the product involves the packaging of loose produce such as cabbages and tomatoes and bundled up produce such as spinach and how this affects the traceability within the supply chain. In the research by Hu, *et al.* (2013) measurements such as weight, variety and origin are recorded for each batch before the cleaning, grading, classification and packaging of the produce occurs, which in this research will be part of product management. According to Regattieri, *et al*. (2007), product identification is essential in the supply chain and the implementation of a traceability system. The research focus was on:

- the packaging and identification of their product i.e. in boxes or loose items
- the product mode of travel throughout the supply chain

4.4 Quality Assurance

Ziggers and Trienekens, (1999) state that the implementation of a quality assurance system ensures increase in sales, profitability and good business which gives the company competitive advantage over others. Fruits and vegetables that come in contact with soil such as strawberries and leafy vegetables like spinach are more prone to microbial contamination (Kirezieva, *et al.* 2013). According to Weinberger and Lumpkin (2007), fruits and vegetables make use of the greatest amount of pesticides and insecticides during their production process hence the need for more stringent safety standards. According to Dinham (2003), the Food and Agricultural Organisation (FAO) has expressed concern on the abundance of cheap, poor quality, unregistered pesticides that flood the market in developing countries and the lack of knowledge, access to information and training of farmers in pesticide use and regulations governing them. According to Peano, *et al.* (2005) food substances are tested for the existence of genetically modified organisms (GMO) as some of these organisms are not allowed and the percentage composition also needs to be assessed and accurate labelling ensured. In a framework designed by Hu, *et al.* (2013) security tests that are done to establish pesticide residue and harmful substances are important in ensuring quality and safety of fresh vegetables. Gonza´lez-Benito, *et al*. (2003), expresses the importance of quality assurance as it is the decisive factor in choosing a supplier rather than the price they offer and that companies that operate globally give more value to quality and reliability. As companies are in constant competition, more stringent measures in quality assurance are often implemented to outbid their competitors in customer satisfaction (Carriquiry and Babcock, 2007). According to Carter, *et al.* (1998), the quality management of products is greatly influenced by buyer-supplier relationships as they dictate how much trust exists and the nature of the relationship. To ensure companies reap the benefits of traceability, good quality assurance should be implemented. In this research with regards to quality assurance, focus was on:

- the information that is recorded during these checks
- the method of information recording and passing on

- the checks performed and cases of repetition
- the cost of sampling and testing, who covers the cost

4.5 Buyer Supplier Relationships

According to Mentzer, *et al.* (2000), Hingley, (2001), the relationships between retailer and supplier are tactical as no long term partnerships exist due to lack of continuity and trust (Hingley, 2005, Lindgreen, 2003, Monczka, *et al*. 1998, Banterle and Stranieri, 2008). Ziggers and Trienekens, (1999) state that for a company to remain competitive within the food supply chain, it should have successful partnerships with its buyers and suppliers and that these partnerships are influenced by the variety of produce such as seasonal varieties. Kekre, *et al*. (1995) states that a limited number of suppliers ensure that the product sourced is of better quality and at a lower cost, hence the buyer supplier relationship is influenced by quality and safety (Ruben, *et al.* 2007, Stringer, *et al*. 2009). In the research it is also evident that some major companies have moved to limited sourcing to improve quality and reduce costs (Kekre, *et al*. 1995). Berry, *et al.* (1994) and Carter, *et al.* (1998), state that buyer supplier relationships are complex as they try to bargain and pit others suppliers against each other. When a number of suppliers exist the price is determined by the customer. However Berry, *et al.* (1994) goes on to explain that the buyer does not always have the upper hand in all cases. According to Clements, *et al.* (2008) connectors and categories exist that aid in the analysis of relationships in fresh produce supply chain. Categories include variation of influence (Scheer and Stern 1992), level of dependence (Heide and John 1988) and degree of information sharing (Holden and O'Toole, 2004). Cannon and Perreault (1999) state the relationship connectors as a) information management which is the open sharing of information beneficial to both parties, b) operational linkages which are systems, procedures and routines developed by the buyer and supplier within the supply chain, c) legal bonds are the binding contractual agreements, d) cooperative norms which are achieving mutual and individual goals beneficial to both parties, and e) specific buyer/seller adaptations which include

investment by buyer or seller into products, processes and procedures. The focus in this research was on:

- the ratio of suppliers to retailers in the market
- the coordination and communication within the supply chain
- the type of contracts that exist
- investments by suppliers and buyers
- variation of influence in decision making
- level of dependence

4.6 Compliance and Certifications

According to Ziggers and Trienekens, (1999), legislation affects the food supply chain at various stages due to food safety concerns and liability in the case of contamination. Certification and compliance has become more desirable to suppliers for supermarkets and retailers who have begun setting their own standards that are more stringent than those prescribed by the government (Stringer, *et al.* 2009), to ensure quality and safe produce. The focus was on:

- the bodies that certify the suppliers
- the laws governing the different players in the supply chain
- the costs incurred with regards to certification and who covers the cost

Section C

In this section, the constraints in implementing traceability highlighted in literature are explained.

4.7 Constraints in traceability

According to the literature, the challenges faced in traceability in section 2.6 will be evaluated in the study to establish if the industry is also affected by the same issues. Florkowski, *et al.* (2009) states that when inadequate information is not being shared, supply chain traceability will be unsuccessful. The lack of information at every point in the supply chain also affects the amount of time it takes to trace a product back hence timeous recalls cannot be effected (Piramuthu, *et al.* 2013). Due to the limited shelf life of fresh vegetables, time becomes a major challenge as all information about a product should be available in the least possible time. The different players in the supply chain may also refuse to share their information to avoid facing liability in the case of outbreaks as highlighted by Smith, *et al.* (2005) and Pouliot and Sumner, (2008) with the US livestock supply chain. Popper (2007) states that labour costs may also be a constraint in the implementation of traceability as manpower needs increase and the need to shoulder the cost is the main challenge. The introduction of traceability will also require implementation costs which according to Hatanaka, *et al.* (2005) will be absorbed by the farmers and subcontractors and not the retailers themselves. Information sharing was evaluated under information management in section 4.2 of the framework. The constraints were deemed necessary as they would provide an insight into why the current level of traceability exists. The constraints that have been raised from literature are:

- the time it took to access the history of a product
- the cost of implementation
- the possibility of being liable

5. Case Studies

A case study was performed of three retail chains in South Africa, which will be referred to as A, B and C in this research. The research would involve an in depth study of the retailers supply chains which would include the producers, packing facilities, fresh produce markets and distribution centres. The supply chains of each retailer were obtained from the retail managers and from interviews with other suppliers.

Retailer A

Retailer A operates a decentralised distribution system. For their fresh vegetable supply, each store can purchase from farmers that are GAP approved or from the Fresh produce market, except for the house brand label which is procured from Global GAP accredited suppliers and obtained from the distribution centre. Farmers that sell their fresh produce at the Fresh produce market adhere to government regulations as stated in the policies in section 2.11 and have to possess a Food business operator (FBO) code. A high care facility does the packaging for the house brand produce and transports it to the distribution centre. Other farmers who have packing facilities on their farms and are GAP approved also package the house brand products and supply them directly to the distribution centre. The supply chain is shown in Figure 6.

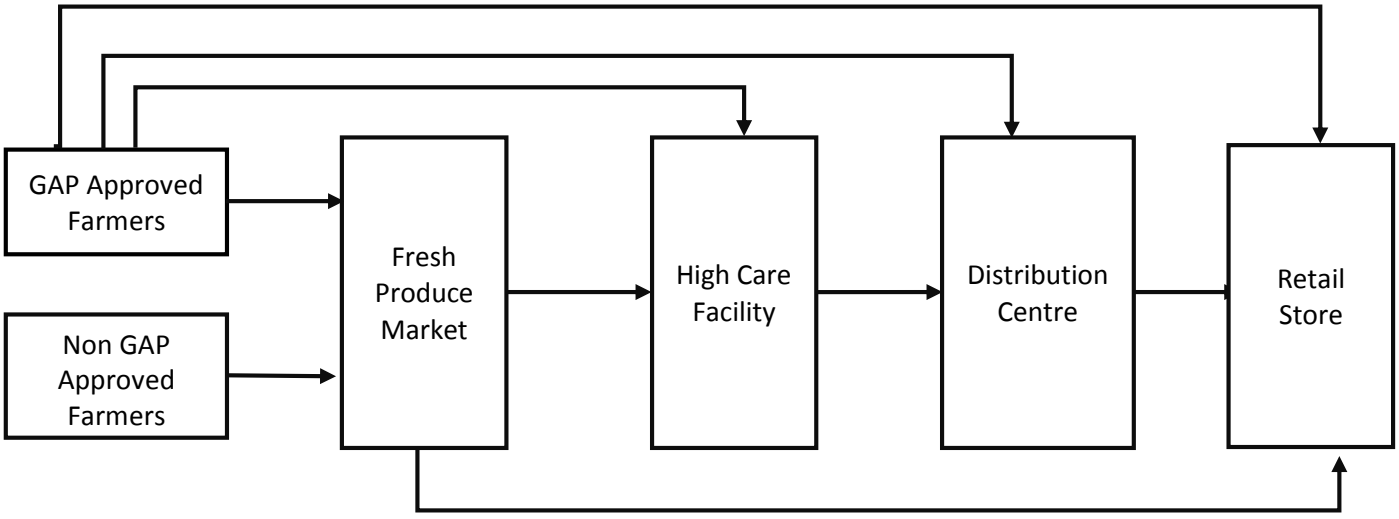

Figure 6. Supply Chain for Retailer A

Retailer B

Retailer B operates a centralised procurement system and all stores obtain their supplies from the distribution centre. All the farmers have packing facilities on their premises and nothing is transported loose or in boxes to be repacked at the distribution centre. The outline of the supply chain is shown in Figure 7.

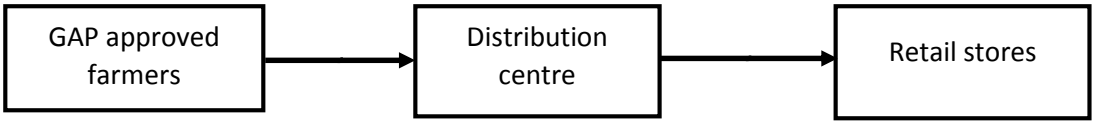

Figure 7. Supply Chain for Retailer B

Retailer C

Retailer C operates a decentralised distribution system. Currently they do not have a packing facility and branded produce. The retailer has two business models for the retail stores, the first being all stores are owned by the company and the second the retail stores are franchises. The retail stores owned by the company procure their fresh produce from the distribution centre and also directly from the farmers. A percentage of produce is obtained from the Fresh produce market through a market agent, from farmers with either local GAP or Global GAP only. The franchise stores can procure their produce from any GAP approved farmers independently. The company owned stores can only obtain direct procurements from farmers that are geographically located close to them. Figure 8 shows the supply chain of the retailer C.

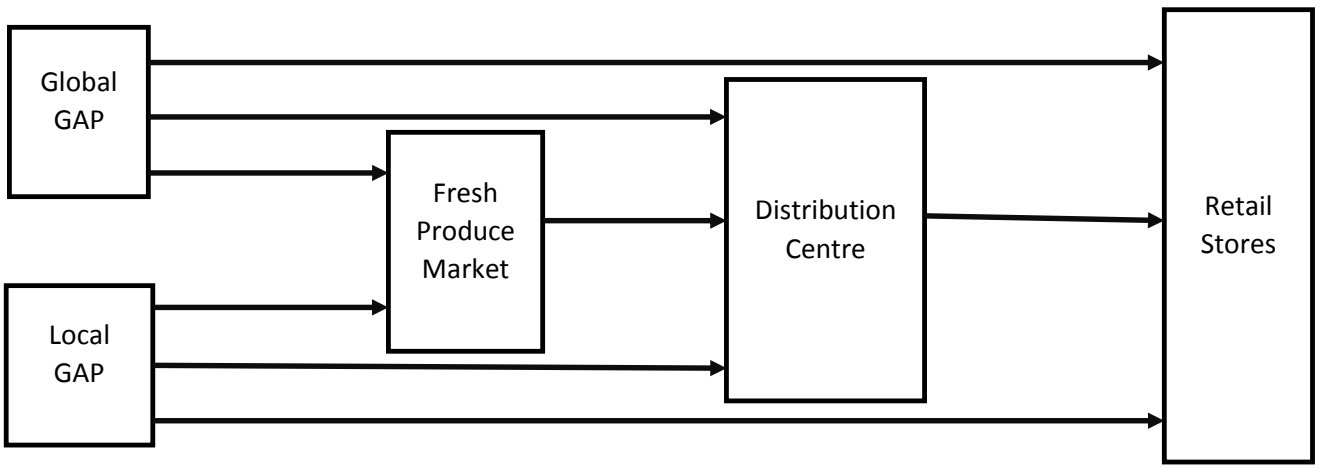

Figure 8. Supply Chain for Retailer C

6. Analysis

In this chapter, the data obtained from the interviews was analysed. For evaluation of traceability and the five supply chain enablers, gap analysis was used. The analysis of the five supply chain enablers was used in evaluation of the current state of traceability. The interviews were again analysed using content analysis to obtain the constraints in traceability in section 6.6.

Section A and B

In this section gap analysis was used for the measurement of traceability and five supply chain enablers' interview results.

6.1 Information Management

Information quality, which is important to obtain effective traceability is attributed to its relevance, usefulness, legibility and ability to be referred to in future. Relevance with regards to the type of vegetable being dealt with, all important information that one might require recorded and passed on. Usefulness would apply to the information being able to be used by the next participant in the supply chain or by the consumer such as fertiliser used, chemicals sprayed or used for washing in the case of allergies. Legibility is an important aspect to recording as it is essential to be able to read and make sense of the information when one refers to it, otherwise it is not useful. Future use is important as this would be essential in trace back cases and when trends within production are analysed. The traceability code that the farmers pass on to the packing facilities contains all or some of the following components, the land number, row or line harvested, date harvested and type of vegetable.

Table 3. Information Management Results

Questions	Farmer 1	Farmer 2	Farmer 3	Low Care	Medium Care 1	Medium Care 2	High Care 1	High Care 2	Fresh Produce Market	DC Retailer A	DC Retailer B	DC Retailer C
Information Recorded	Seed Code	Seed Code	Seed Code	Number of lugs received	Field Harvested	Room Harvested	Farmer Number, FBO code	Land Number	Time of Delivery	Time of Delivery	Time of Delivery	Time of Delivery
	Chemical added to compost	Fertiliser	Fertiliser	Field Harvested	Date of Harvest	Number of Harvester	Units Received	Date of Harvest	Agent Name	Truck Temperature	Truck Temperature	Truck Temperature
	Room Grown	Chemical Sprayed	Chemical Sprayed	Weight of Produce	Weight of Produce	Number of Pallets	Mass per unit (kg)	Weight of Produce	Quantity Received	Quantity Received	Quantity Received	Quantity Received
	Date of Harvest	Land Grown	Land Grown	Date of Harvest	Chlorine Water Level	Weight and variety of mushroom	Market good received number		FBO Code	Supplier code	Supplier code	Supplier
		Date of Harvest	Date of Harvest	Type of Vegetable	Type of Vegetable		Grower Initials		Goods Received Number			
							Chlorine Water Level					
							Time Tested					
							Sodium Metabisulphate Level					
							Type of Vegetable					

Questions	Farmer 1	Farmer 2	Farmer 3	Low Care	Medium Care 1	Medium Care 2	High Care 1	High Care 2	Fresh Produce Market	DC Retailer A	DC Retailer B	DC Retailer C
Method of Information Capture at Receiving	Computer	Computer	Pen and paper	Computer	Pen and paper	Computer	Pen and paper	Pen and paper	Pen and Paper	Pen and paper	Pen and paper	Pen and Paper
Method of Information Capture when Processing	Computer	Computer	Pen and Paper	Pen and Paper	Pen and Paper	Pen and Paper	Pen and Paper	Pen and Paper	Computer	Computer	Computer	Computer
Quality of Information	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Method of Record Storage	Computer	Computer	Paper Files	Paper Files	Paper Files	Paper Files	Paper Files	Paper Files	Computer	Computer	Computer	Computer
Time Stored	Unlimited	Unlimited	One year	Unlimited	One year	Unlimited	Unlimited	One year	Unlimited	Unlimited	Unlimited	Unlimited
Information Received from Downstream	N/A	N/A	N/A	Traceability code	Traceability code	Traceability code	Farmer number, grower initials	Traceability code	FBO Code	Product type, Sell by date, Weight, Supplier code	Product type, Sell by date, Weight, Supplier code	Product type, Product Code
Information Passed on Upstream	Traceability code	Traceability code	Traceability code	Product type, Sell by date, Weight, Supplier code	Product type, Sell by date, Weight, Supplier code	Product type, Sell by date, Weight, Supplier code	Product type, Sell by date, Weight, Supplier code	Product type, Sell by date, Weight, Supplier code	FBO Code	None	None	None

6.2 Product Management

In this section, the results about the processes involved after postharvest are shown in Table 3 for the farmers, facilities and distribution centres. Lugs are used to carry the produce from the farm to the pack house and these are plastic crates that are reusable. The packaging contains a code which is a sequence of numbers that are placed on the packages by the manufacturer. The packaging codes are used for traceability in the case of a complaint such as, packaging not closing properly and presence of defects.

Table 4. Product Management Results

Questions	Farmer 1	Farmer 2	Farmer 3	Low Care	Medium care 1	Medium care 2	High care 1	High care 2	Fresh Produce Market	DC Retailer A	DC Retailer B	DC Retailer C
Processes Performed on Produce	None	None	None	Sorting	Removal Of Outer Leaves On Vegetables Such As Onions And Leeks	Manual Checking Of Pallets For Correct Sorting	Vegetables Are Washed	Peeling And Washing Done By Machines	None	None	None	None
				Labelling	Vegetables Are Packaged	Weighing	Peeling And Cutting Done By Hand Or Machine Depending On Vegetable	Sorting By Machine And Manual				
				Packing	Washing To Remove Soil From Roots And Leaves In Chlorine Water	Sealing And Labelling	Washing And Treating Vegetables that Change Colour	Packing Done By Machine				
				Weighing	Roots And Leaves Trimmed Or Removed According To Retailer Specification		Packing	Weighs And Labels				
					Weighed And Labelled		Waste Is Weighed And Recorded					
							Sealing And Labelling					

Questions	Farmer 1	Farmer 2	Farmer 3	Low Care	Medium care 1	Medium care 2	High care 1	High care 2	Fresh Produce Market	DC Retailer A	DC Retailer B	DC Retailer C
Type of Packaging Used	Punnets	Lugs	Lugs	Punnets	Punnets	Punnets	Punnets	Plastic Bags	Boxes	Lugs	Lugs	Lugs
				Plastic Bags	Plastic Bags		Plastic Bags	Plastic Bags	Punnets			
				Plastic Wrap	Plastic Wrap	Plastic Wrap	Plastic Wrap		Pockets			
Information Recorded on Packaging	Packaging code	None	None	Packaging Code	Packaging Code	Packaging Code	Packaging Code	Packaging Code	None	None	None	None
Information on Label	Traceability code	Traceability code	Traceability code	Sell By Date	Sell By Date	Sell By Date	Sell By Date	Sell By Date	FBO Code	Sell By Date	Sell By Date	Sell By Date
				Supplier Code	Supplier Code	Supplier Code	Supplier Code	Supplier Code	Quantity	Supplier Code	Supplier Code	Packer Logo
				Retailer Logo	Retailer Logo	Retailer Logo	Retailer Logo		Type of vegetable	Retailer Logo	Retailer Logo	Price
				Price	Price	Price	Price		Grower Initials	Price	Price	
Transportation Used	Own Trucks	Own Tractors or trucks	Own Tractors or trucks	Own Trucks	Own Trucks	Own Trucks	Own trucks	Own trucks	None	Own trucks	Own trucks	Own Trucks
Method of Tracking Vehicles	None	None	None	GPS Not Real Time	GPS Not Real Time	Real Time Tracking	Tracker Downloaded After Trip	GPS Not Real Time	None	Real Time Tracking	Real Time Tracking	Real Time Tracking

6.3 Quality Assurance

In this research, the quality checks performed by the participants were under investigation. The external attributes and the organoleptic checks were varied and this could be attributed to the difference in the vegetables grown and processed by the participants. Organoleptic refers to those aspects that can be detected by the senses such as taste, smell, sight and feel. The cold chain refers to the monitoring of temperature in a supply chain, to obtain optimum conditions during manufacturing, processing, transportation and storage of produce. The cold chain is important in ensuring quality of produce is maintained after postharvest. A Brix test is used to measure the level of sugar content, the higher the level the sweeter the product. Table 4 shows the results from the analysis of the interview questions with regards to quality assurance.

Table 5. Quality Assurance Results

Questions	Farmer 1	Farmer 2	Farmer 3	Low Care	Medium Care 1	Medium Care 2	High Care 1	High Care 2	Fresh Produce Market	DC Retailer A	DC Retailer B	DC Retailer C
Type Of Vegetables	Mushroom	Tomatoes	Carrots	Tomatoes	Leeks	Mushroom	Butternut	Carrots	Assorted	Assorted	Assorted	Assorted
		Cabbages	Leeks	Cabbages	Onions		Pumpkin					
		Cucumbers	Onions	Cucumbers	Radishes		Potatoes					
		Lettuce	Radishes	Lettuce			Carrots					
		Herbs		Herbs			Peppers					
							Cabbages					
Organoleptic Checks Performed	None	None	None	Taste	None	None	Flavour	Brix Test	Appearance	Appearance	Appearance	Appearance
							Flesh Colour					
							Aroma					
							Flesh Texture					

Questions	Farmer 1	Farmer 2	Farmer 3	Low Care	Medium Care 1	Medium Care 2	High Care 1	High Care 2	Fresh Produce Market	DC Retailer A	DC Retailer B	DC Retailer C
							Appearance					
External Attributes Checked	Fly Damage	Pest Damage	Pest Damage	Colour	Insect Damage	Fly Damage	Freshness	None	Freshness	Sun Damage,	Sun Damage,	Sun Damage
	Size	Disease Damage	Disease Damage	Size	Disease Damage	Size	Insect Damage		Disease	Appearance	Appearance	Appearance
				Shape			Disease Damage		Decay	Cleanliness	Cleanliness	Cleanliness
							Sunburn/ Wind/ Hail Damage			Cold Chain Maintenance	Cold Chain Maintenance	Cold Chain Maintenance
							Uniformity			Meeting Of Specifications	Meeting Of Specifications	Meeting of Specifications
Microbial Test	Yes	Yes	Yes	Yes,	Yes	Yes,	Yes	Yes	Yes	Yes	Yes	No
	Random Frequency	Random Frequency	Random Frequency	Monthly	Bi-monthly	Monthly	Random Frequency	Bi-monthly	Random Frequency	Monthly	Monthly	
Maximum Residue Test	Random	Random	Random	Random	Random	Random	Random	Random	Random	Random	Random	No
Cold Chain Monitoring	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes

6.4 Buyer Supplier Relationships

The buyer supplier relationships are important as they influence the adoption of traceability. This area does present a challenge as participants are careful of their responses to interview questions and resolve to vague responses such as good and cordial. The analysis in Table 6 shows the actual responses to direct and indirect interview questions on relationships.

Table 6. Buyer Supplier Relationships

Questions	Farmer 1	Farmer 2	Farmer 3	Low Care	Medium Care 1	Medium Care 2	High Care 1	High Care 2	Fresh Produce Market	DC Retailer A	DC Retailer B	DC Retailer C
Communication from retailer	Growing Program, Produce Specifications, Policy Requirements	Growing Program, Produce Specifications, Policy Requirements	Growing Program, Produce Specifications, Policy Requirements	Growing Program, Produce Specifications, Policy Requirements	Growing Program, Produce Specifications, Policy Requirements	Growing Program, Produce Specifications, Policy Requirements	Growing Program, Produce Specifications, Policy Requirements	Growing Program, Produce Specifications, Policy Requirements	None	N/A	N/A	N/A
Type of contracts	Growing Program	Growing Program	Growing Program	Growing Program	Growing Program	Growing Program	Growing Program	Growing Program	None	None	None	None
Who influences decision making	Retailer	Retailer	Retailer	Retailer	Retailer	Retailer	Retailer	Retailer	Retailer, Consumer, Government	Retailer, Consumer	Retailer, Consumer	Retailer, Consumer
Investment by supplier	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	N/A	N/A	N/A
Investment by retailer	No	No	No	No	No	No	No	No	No	N/A	N/A	N/A

Questions	Farmer 1	Farmer 2	Farmer 3	Low Care	Medium Care 1	Medium Care 2	High Care 1	High Care 2	Fresh Produce Market	DC Retailer A	DC Retailer B	DC Retailer C
Dependence on supplier	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	None	None	None	None
Dependence on retailer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	N/A	N/A	N/A
Relationship with suppliers	N/A	N/A	N/A	Self-supply	Self-supply	Self-supply	Very Good	Self-supply	Good	Good	Good	Good
Relationship with retailers	Good	Good	Cordial	Good	Cordial	Good	Very Good	Cordial	None	N/A	N/A	N/A
Retailer supplied	A	B	A	B	A	A	A	A	A	A	B	C
	B		B		B	B		B	C			

6.5 Certification and compliance

The certification such as Global GAP is a requirement to supply the retailers and all farmers possess it.

The table 7 shows the results from the analysis of the interview responses.

Table 7. Certification and Compliance

Questions	Farmer 1	Farmer 2	Farmer 3	Low Care	Medium Care 1	Medium Care 2	High Care 1	High Care 2	Fresh Produce Market	DC Retailer A	DC Retailer B	DC Retailer C
Certifications	Global Gap	Global Gap Organic	Global Gap	None	FSI	HACCP Halaal	FSI	FSI	None	None	None	None
Cost Of Certification Covered By	Self	Self	Self	N/A	Self	Self	Self	Self	Self	N/A	N/A	N/A
Number Of Audits For Certification	Yearly	Yearly	Yearly	N/A	Yearly	Yearly	Yearly	Yearly	Yearly	N/A	N/A	N/A
Number Of Audits By Retailer	Yearly	Yearly	Yearly	Yearly	Yearly	Yearly	Yearly	Yearly	None	N/A	N/A	N/A
Renewal Of Certifications	Annually	Annually	Annually	N/A	Annually	Annually	Annually	Annually	Annually	N/A	N/A	N/A

Section C

6.6 Constraints in traceability

The constraints were analysed using content analysis. The analysis was a two stage process as outlined in the methodology in chapter 3. Firstly the interview transcripts were analysed for information relevant to constraints in traceability as highlighted in literature and any new constraints that emerged. The first stage of analysis is shown in Table 8.

Table 8. Example of Coding Framework

Interview Transcript	**Constraints in Traceability**
Interviewer: What quality checks do you perform?	
Participant: We do random checks its' impossible to do every batch. We do the chemical analysis and the microbial analysis. It is because you pay per sample and obviously its' expensive. We have looked at other alternatives to test that don't require labs but the technology is not available in South Africa.	Costs Costs
Interviewer: What information do you record after purchasing?	
Participant: We have a receiving checklist and on that list we check the organoleptics of the product i.e. any sun damage or the external and internal attributes of the products.	None

A second analysis was performed in which the data highlighted in the first analysis was further analysed for any hidden constraints or those overlooked. In the second analysis the interview questions were no longer considered, only the participants' responses were relevant. Table 9 shows the analysis.

Table 9. Constraints in Traceability

Participant Responses	**Constraints in Traceability**
Global GAP are auditing the record keepings, obviously they will pull files and ask questions about what has been applied, what did you plant when did you plant so all of that is on file but, that to me is not relevant to the end consumer, the customer really doesn't want to know when the farmer planted the tomatoes, what the customer wants to know is, is it safe to eat, is it nutritious, is it healthy, is it good quality. So the main purpose of our traceability system has to do with our quality and we have a quality problem that we can trace them back to the farm and identify who was at fault and also what lands were at fault.	Consumer awareness Liability
I think the problem with a system is if you take the micro testing and the residue testing it's a slow process its' not instant so you will send a sample today and get the results after a week. But that product is already gone its already in the system so you can't stop it you selling the product, you sampling the product so after the result you only get five days after the product has been on the shelf so it could be sold already. In terms of technology if we had an instant system whereby we pointed an infrared gun or something as you would do for temperature get a reading of microbial contamination or pesticides that would be great.	Time Technology
In the case of something being contaminated I will get you the information in a day.	Time

Participant Responses	Constraints in Traceability
We do maximum residue limits (MRL) we do bi annually on the produce just to make sure there isn't any chemicals. We send to SABS. It costs us a lot for the tests. It takes almost a month for the results to come out. Its only one laboratory that's doing these tests. That is a bit of a problem.	Cost Time
I think the costs are one thing and if you are going to implement a traceability system it is pointless doing it for retail, you must remember that, take potatoes for instant, 65% of all potatoes sold in this country are sold in the municipal markets they are not sold at retails and of that 65% about 40% is bought by hawkers and then resold to customers. I am not saying only potatoes is the only crop. If we are going to introduce the high tech system we can't just go to a farmer and say do it for us you know, the economies of scale, all these high tech systems cost lots of money so you almost have to do it as an industry. I think costs are often preventative when it comes to these high tech systems.	Cost Competition Technology Cost
I can't say there is no need, I think the question is the cost and who is going to pay for it and how do we implement it. Yes sure there is a need for it I mean for a simpler system electronic system will be far much easier but you not going to the average farmer paying hundreds of thousands of rands for scanners and barcode readers and what have you when he doesn't need to do that when he supplies the municipal markets.	Cost Technology Competition

Participant Responses	**Constraints in Traceability**
The responsibility of the poison or contamination always lies with the primary producer the farmer. He carries the ultimate blame but you have to prove that. So you have to go through a process of law to prove that. If a report is laid when all the stock has gone out we won't know. Its' impossible to test every product, every day, every producer what we can do is random checks. We draw random samples and then send them to SABS and then they send us results to say what unregistered products have been used, their analysis can only identify a certain amount they can't identify everything. So they have a band that they test for so even if there is a product that was used that's not in this band they won't pick it up. So that complicates it even further. With increase in the band the cost also increases and becomes so exorbitant that you cannot run a business as we cover our own costs for testing.	Liability Cost
We don't pass on any of that, we control that at a central point. And we believe that the stores and consumers have the comfort in the fact that we have procured the item correctly. So we don't feel it's necessary to pass on that information to the stores.	Consumer awareness
There is little profit in this business now because of all these things we need to institute such as tests and certifications	Cost
To have fancy digital traceability systems is not practical. At the end of the day you are working with farmers and for them working with computers and having all these electronic systems for them it's a very different concept. Yes there are some young and upcoming farmers	Technology Age of farmers

Participant Responses	Constraints in Traceability
that are into technology. A lot of farmers are not equipped to input the information in an electronic system. Making use of cellphone technology would help the farmers record their activities.	Education of farmers
I think there have been many cases of food contamination but I think in South Africa we have the worst reporting and in Britain every food illness gets recorded and people will go to hospital and it's not like that here. The infrastructure presents a challenge. And the way people are educated to understand how and what is, education plays a huge role in this process. Even with our staff training and development is our biggest thing. We continuously have to train people to understand that this is basic hygiene. And also training farmers and educating them that this is how it works.	Consumer awareness Consumer awareness
But you know with government they don't want to be seen as over regulating especially with farmers and small farmers its peoples' livelihoods. All these standards come at a cost for compliance or the burden of proof. If government can play a supporting role through extension officers and us at the end of the supply chain we can help with the training and testing.	Legislation Cost Liability
We haven't had a customer complaint about being sick in which case a technologist comes from the retailer and checks everything and if we are at fault we will be liable.	Liability

Participant Responses	**Constraints in Traceability**
It's not legislated that we have to put any traceability on the produce. We want our consumers to understand that we meet all our requirements and therefore they should feel satisfied that we have taken care of the backing processes on their behalf. The packaging legislation we comply to give the customer information and to meet the requirements of DAFF as to what we need to communicate on that packaging.	Legislation
We receive produce twenty four hours. It is not possible but we go to the floor to check on daily basis. Because of high volumes we receive we are unable to check everything.	Cost
Because every retailer needs to be responsible in the fact that they provide consumers with food safe products. And the complication with that is if there are independent processes of adherences with all the respective retailers, a farmer has to go through four or five audits and we suggesting that we have one audit which we will adopt and which we will support.	Legislation Cost
How much resources are you going to put in a system for something that happens once instead the resources should be put in a system that is sustainable to minimise risk. With technology we can obtain full traceability provided it's cost effective	Cost Technology

Participant Responses	Constraints in Traceability
That's what we all wish for because the retailer auditor may say paint the wall white and the HACCP auditor will say why paint the wall white, they don't have a standard that's the same, which makes it difficult because sometimes we spending quite a lot of money on something and the next auditor says it wasn't really necessary. It could be easier with one standard everyone was following but, the whole standard like personal hygiene, water all that is mostly the same but practical things in the pack house they might be audited differently making it difficult.	Legislation Cost
It's a good practice but it's not law unless you deal with drugs. The only thing we ask is their spray program and their list of pesticides because that's what we test. If we do find problems with their weight we will report to them, and if they disagree they send us checks and we ask if their scale is calibrated.	Legislation
We don't take ownership of the goods neither are the products consigned to us. It still belongs to a farmer until its' sold to a buyer. Its' in the custodianship of a market agent. We are landlords here we get commission only. Unless product is damaged on our premises and its' the markets fault in our cold rooms	Liability
We do not have full capacity of staff to inspect every consignment as well.	Cost
The cost is high even for our in house laboratory. It is high maintenance for accreditation with SANAS and consumables.	Cost

Participant Responses	**Constraints in Traceability**
And if you look at the consumer protection act, we are doing our part by monitoring pesticide residue. But we cannot put in a system of until it is tested within the limits and then clear it as this brings a number of things to a standstill.	Legislation Time
What the retailers do is they pass the burden of proof to the farmer or producer. So hence we have Global GAP and local Gap which forces farmers to have good agricultural practices at the time of supplying and distribution	Liability
We send microbial tests to outside labs. Unless there is an outbreak somewhere and we ask for results as soon as possible then they want more money.	Cost
Some farmers feel they don't need certification because they don't want to be dictated to unless its law.	Legislation
We get a consignment in and we have batch numbers and the challenge is we don't have barcodes on the boxes. So we looking at a system that can physically identify that this box is from this batch. We currently rely on the farmer and agent to tell us that.	Management of produce
Over a six monthly cycle we will make sure everything has been tested. They are random but we will get to a stage where we test everything. The cost of all the tests is the producers.	Cost

Participant Responses	**Constraints in Traceability**
We do random checks it is impossible to do every batch. We do the chemical analysis and the microbial analysis. It is because you pay per sample and obviously its' expensive. We have looked at other alternatives to test that don't require laboratories but the technology is not available in South Africa.	Cost Technology
Cost of compliance, small producers and if we are to implement our own traceability system it becomes cost prohibitive. That's why we are supporting the Consumer Goods Council of South Africa. If there is a standard for the industry we want to adopt that standard to minimize costs for the producer.	Cost Legislation
If you understand the consumer protection act, ultimately it is the retailer and the retailer has to prove liability to the supplier, so that's why it is important that we get our suppliers to comply because we know that it is our responsibility.	Liability
The challenge for retailers in general is bought in product from the market place or neighboring farmers, keeping the trace codes on during production procedures and labeling practices.	Management of produce

7. Results

In this section the results obtained from the analysis in chapter 6 are presented with reference to the subheadings in the theoretical framework. Other results and observations which could not be tabulated for analysis are explained in the relevant sections.

The three farms visited all exhibited vertical integration with the establishment of packing facilities and owning the transportation of their produce. Results are shown for the three farms, five packing facilities, fresh produce market and the three distribution centres (DC) for retailers A, B and C.

Section A

7.1 Evaluation of traceability

To measure the traceability, a scale of levels had to be implemented and these are shown in Table 10, 11 and 12. Each retailer was evaluated with reference to the scales and the information obtained from the interviews that was analysed in chapter 6 was used. The comment section in the table justifies the level the particular aspect was given and the state of the supply chain.

Table 10. Evaluation of Traceability for Retailer A

Scale

Levels	Traceability Rating
1	None
2	Partial
3	Full

Aspects	Retailer A	Comments
Product traceability	2	Tracking of transportation was not in real time with some suppliers hence the whereabouts of the product was not known at all times.
Process traceability	2	Cold chain monitoring was performed throughout the supply chain except for produce from fresh produce market. Sequence of activities was not available at every point in the supply chain as no information was passed upstream hence no history existed. Tests on contaminates was not done on samples of all batches that were produced.

Aspects	Retailer A	Comments
Genetic traceability	2	The variety of the produce was known and included on labelling throughout the supply chain even on produce obtained from the fresh produce market. The seed supplier and genetics were only known by the farmer and not passed to others upstream.
Inputs traceability	2	The information on inputs was only available at each level and nothing was passed upstream. The maximum residue and water quality tests were performed and again information was not passed on.
Disease and pest traceability	2	Tests were performed on the produce and the information was not passed either upstream or downstream.
Measurement traceability	2	Calibration was not uniform at all points in the supply chain as some suppliers did not use a certified company.

Table 11. Evaluation of Traceability for Retailer B

Scale

Levels	Traceability Rating
1	None
2	Partial
3	Full

Aspects	Retailer B	Comments
Product traceability	2	Tracking of transportation was not in real time with some suppliers hence the whereabouts of the product was not known at all times.
Process traceability	2	The cold chain was monitored throughout the supply chain. Sequence of activities was not available at every point in the supply chain as no information was passed upstream hence no history existed. Not all produce was tested for contaminates as tests were performed on samples obtained from random batches.

Aspects	Retailer B	Comments
Genetic traceability	2	The variety of the produce was known and included on labelling throughout the supply chain. The seed supplier and genetics were only known by the farmer and not passed to others upstream.
Inputs traceability	2	The records on inputs and chemical tests remained with either the farmer or facility and was not passed upstream.
Disease and pest traceability	2	The tests were performed at every point in the supply chain but no information was passed either upstream or downstream.
Measurement traceability	2	Calibration was performed on thermometers and scales by some participants in the supply chain using a certified company.

Table 12. Evaluation of Traceability for Retailer C

Scale

Levels	Traceability Rating
1	None
2	Partial
3	Full

Aspects	Retailer C	Comments
Product traceability	2	Tracking of transportation was not in real time for some of the suppliers.
Process traceability	2	The cold chain monitoring was not uniform across the supply chain. Sequence of activities was not available at every point in the supply chain as no information was passed upstream hence no history existed. Not all produce was tested for contaminates as tests were performed on samples obtained from random batches.

Aspects	Retailer C	Comments
Genetic traceability	2	The variety of the produce was known and included on labelling throughout the supply chain. The seed supplier and genetics were only known by the farmer and not passed to others upstream.
Inputs traceability	2	The records on inputs remained with the farmer. The test results however, were passed on upstream to the retailer distribution centre.
Disease and pest traceability	2	Tests were performed by some of the farmers and results passed on to retailer, but produce obtained from the market did not have test results.
Measurement traceability	2	Calibration was performed by some participants within the supply chain using a certified company

Section B

7.2 Information management

Table 2 shows the information management related results from all the participants in the research after the gap analysis had been performed. The area of concern in the research was the quality of information they recorded and the amount they then passed on to others in the supply chain. Farmers recorded seed, soil, pesticide, fertiliser and field specifications which are all requirements for Global GAP. For the farms that exhibit vertical integration a code was passed from the farm to the packing facility which is referred to as a 'traceability code'. They include the land number and line or row planted, date harvested among other things. It was noted that those in the packing facility had no idea what the code meant except that it was for traceability. The code was recorded on the sheets with the quality information for the batch to be packaged when the produce was received at the packing facility. The high care facility, the distribution centre for retailer C and the retail stores for retailer A and C obtained produce directly from the fresh produce market which was packaged in boxes or pockets with grower initials and Food Business Operator (FBO) codes which are specific for a farmer. The requirements to obtain an FBO code are to follow the growing and spraying programs set out by the South African Department of Agriculture. In case of contamination the participants stated that they would be able to obtain produce information in four to twenty four hours.

The participants did not make use of technology such as barcode readers and RFID tags for information storage. Although barcodes are present on the packaging and labels for produce, they are only used for check out in retail stores after consumer purchase. Two farms, fresh produce market and all three retailer distribution centres used computers for information capture and storage, while the remaining participants used pen and paper.

The results are obtained from the analysis in chapter 6. In this section the results are presented with reference to the focus areas in the theoretical framework.

- All farms recorded a lot of information about the vegetables and the processes they performed, they did pass on the traceability code when the packing facility was on the farm. For those that purchased at the fresh produce market, the information they obtained was the details of the farmer such as name and FBO code but not the details of the processes performed on the vegetables from planting to harvesting which were important for traceability.
- It was noted that the information recorded was very useful and accurate, all participants were consistent in the information they recorded about the processes performed.
- Technology use in information gathering was absent, however computers were used by some participants for storage of information. Most participants made use of pen and paper to record and store their information.

7.3 Product management

No value adding processes were done on the farms. The distribution centres and fresh produce market only receive packaged goods and loose produce. The retail stores for retailer A and C purchased some loose and packaged products from the fresh produce market for sale in their stores but this was at the owner of the franchises' discretion as to what they source and stock in their store. For retailer A stores, only the house brand products were procured from the distribution centre, and were packaged at high care facility 1. The high care facility sourced forty percent of their vegetables from the Global GAP approved farmers they were referred to by the retailer and sixty percent from the fresh produce market. The farmers that sell at the fresh produce market are not always Global GAP and local GAP approved but have to adhere to government regulations. For traceability all their boxes or packaging are marked with a Food Business Operator (FBO) code which is specific for a farmer. The requirements to obtain an FBO code are to follow the growing and spraying programs set out by the South African

Department of Agriculture. The programs stipulate the chemicals to be sprayed and the time the farmers should wait before harvesting to ensure they do not exceed the maximum residue limits in their harvested produce. Due to variations in season the high care facility was sometimes forced to obtain their produce from the market as the vegetables were out of season with the GAP approved farmers. Retailer C also sourced a percentage from the fresh produce market, but dealt with GAP approved farmers only. The retailers do not deal directly with the fresh produce market but make use of independent market agents. The fresh produce market has a database with the farmer details and certifications which the market agents use to obtain GAP certified farmers. The farmers who participated in this research also supplied the fresh produce market with those vegetables that are surplus and did not meet the product specifications of the retailers. The produce was packed into boxes and pockets or packaged in their own branded packaging with their FBO code and grower initials.

The specifications for the packaging and its supplier were dictated by the retailer and it was mandatory to source the packaging from that recommended supplier, as the retailer negotiates a price on behalf of all its produce suppliers. All farms and packing facilities recorded the packaging code for traceability. The packaging specifications for the fresh produce market are set in the Agriculture product standards act supplied by the government for the different vegetables.

During the interviews with all packing facilities it was noted that no mixing of products from different batches occurred. When a batch of butternuts from an individual farmer or field was received, it was processed until finished before a new batch from a different field or farmer was added. They also utilised the first in first out rule. This ensures that no batch mixing occurs that complicates traceability. Those products that contain a variety of vegetables such as salads and stir-fry mixes, were observed to contain no batch mixing as well. All the carrots julienne would be from one farmer in a batch of stir-fry packages. The small size of the packing facilities and the amount of packages they needed to produce at a certain time for distribution contributed to avoiding batch mixing. The fresh produce

market did not have a labelling system in place to avoid mixing of batches delivered from a single farmer but on different days. The boxes had no delivery date markings or batch numbers for identification and had to rely on the farmer and market agent.

The mushroom farm that supplies both retailer A and B performed mock recalls and trial runs twice a year to ensure their traceability was in good working order. This was done by contacting all the different people they supply and requesting they remove their product from their shelves and return it to them. No indication that it was a trial run was given even to the workers on site as this would compromise the performance. An evaluation of their performance was conducted and then work returns to normal. No other farm or packing facility did this although no recorded recalls have been effected within the country to date. The fresh produce market had stopped performing the mock recalls altogether as they felt it was not necessary as no fresh produce has been recalled to date. Retailer C also performed mock recalls yearly.

The results for product management that were obtained from the analysis in chapter 6 are presented with reference to the focus areas in the theoretical framework in section 4.2.

- The cleaning, grading, classification and packaging of produce for the retailers is governed by the specifications that have been given to the supplier. The loose products are packaged in boxes that have supplier information and type of vegetable. No specifications are given to the fresh produce market when retailers purchase their produce.
- All farms, packing facilities and retailers owned their trucks and transported the produce to the distribution centres. The tracking of transportation was varied with some using real time tracking while others were not real time. Retailer C sometimes provided transport from farms to their distribution centre. The fresh produce market did not own trucks or provide transportation.

7.4 Quality Assurance

Some facilities had a standard schedule they used to check for quality such as high care 1 but the others relied on the experience of their staff and had not set out or printed standard format to adhere to. The distribution centres also performed checks on the produce in packages before accepting a delivery. Cold chain monitoring was not uniform as the fresh produce market did not check temperature of produce on delivery or during transportation. Trucks used by all participants besides the fresh produce market, were refrigerated and were checked for cleanliness and temperature before loading and before unloading at their destination. Deviations of the truck refrigerator temperature will lead to rejection of products. Product temperature is also taken before offloading.

Microbial and chemical analysis tests were performed monthly on the low, medium and high care facilities. They test the knives, cutting boards, cleaning cloths, water supply and swab the hands of the workers. These tests are also random and ensure hygiene of work area for food preparation and packaging. These microbial tests take shorter time than maximum residue limit tests for results to be obtained, which is about three days. Independent laboratories perform these tests.

Checking for quality was not uniform across the participants as shown in Table 4. Some did taste tests and Brix tests, while others did only visual test for colour, size and cleanliness and then packaged the vegetables. The difference in the tests could be attributed to the difference in vegetables grown and processed at the facilities. It was noted that the tests would be performed on a sample of two percent from the batch. It should also be noted that the samples count as a loss as some of the tests are destructive and hence they cannot take larger samples as this would prove too costly to the business. Some fresh vegetables such as potatoes and onions were not tasted as the workers stated their taste was undesirable and only performed visual tests. Quality checks at the fresh produce market were random and not all produce sold would be checked.

To ensure that the weights are accurate, all scales are calibrated twice a year. The thermometers are also checked for accuracy with reference to a set standard. This is a requirement for Global GAP and encouraged by government regulations. The calibration has to be performed by a certified company. This is important to traceability and is used to evaluate measurement traceability throughout the supply chain.

The analysis produced the following results:

- Information recorded during checks varied among participants, as they produced different vegetables for the retailers.
- Some participants had a schedule of checks to perform that they filled in. No information was passed upstream about checks performed or tests done.
- All participants perform maximum residue and microbial tests. It was noted that repetition does occur as within the supply chain testing on the same fresh produce is done by the farmer, packing facility and distribution centre. Retailer C only, has suppliers submit their test results and does not perform any independent tests. The fresh produce market has a laboratory onsite to perform maximum residue test.
- Not all produce grown or packed and distributed is tested, as all participants perform tests on random samples. All participants cover their own sampling and testing costs.

7.5 Buyer Supplier Relationships

From the interview one word answers were only obtained to questions regarding the state of their relationships. The participants were not willing to go into detail about their relationships. One participant did explain a scenario in which the retailer had requested that they implement recycling measures in order to continue supplying them. This was costly to the farm initially to set up a water

recycling plant, although it will save them in the long run. This showed the level of influence the retailer had on the suppliers with regards to decision making. The retailers do not deal directly with the fresh produce market but make use of a market agent. No relationship exists between the retailers and the fresh produce market.

The retailers do not have legal binding contracts with the farmers. Each farmer receives a growing program from the retailer for each growing season which stipulates the amount of fresh vegetables that they will need to supply the retailer at any given time. The growing program is developed from forecast of sales based on the past sales in the same season. There are two growing seasons in a year and the growing programs are given to farmers well in advance to enable them to prepare to meet their set targets on time. Failure to meet the set target amount will result in their growing program being revised and reduced amounts being allocated in the next growing season. The farmers can ultimately lose the business with the retailer if they continue to fail to meet the required amounts to be supplied. The farmers are dependent on retailer business as all farms visited stated the retailers gave them the most business and they only sold their surplus at fresh produce markets. There are other factors that a farmer cannot control such as hail, sun and wind damage to crops that may affect the meeting of the target supply amount, the retailer can only tolerate so much and the farmer may be at risk of losing retailer business if they continue to give excuses.

There a few farmers who have the required certifications and can handle the large quantities required by the retailers and hence most of the farmers and packing facilities supply two retailers in this research. Each supplier receives a set of product specifications on each vegetable they supply to the retailer. The product specifications differ from one retailer to the next. When one farm supplys two retailers with salad onions, retailer A may specify that they want the onions with roots and leaves and six onions per bag, while retailer B may specify that they do not want roots and leaves and the bag should be one hundred grams. The farmer and packing facility have to adhere to these specifications or their produce will be rejected and they risk running losses and losing retailer business. To supply

the fresh produce market no product specifications such as those for retailers are given. The market has different classes for produce i.e. class one, two, three and lowest class and only produce not suitable for human consumption is rejected. The different classes ensure that everyone can purchase produce in the class they afford and this ensures food security without compromising food safety. The retailers only accept the first class. From the analysis in chapter 6, the following results were obtained.

- There are few suppliers as some of the participants in the research supplied two retailers, only two participants supplied a single retailer. Suppliers are also limited as some do not have the required certifications to supply retailers directly but are able to sell their produce at fresh produce markets.
- No legal binding contracts are signed, only growing programs are issued and opportunity buying is done at the Fresh produce market.
- The retailer influences the decisions made by the farmers. Only farmers supplying the Fresh produce market are not affected by retailer policies such as certification and recycling.
- There is no shared investment towards a common goal. The farmers and suppliers do not get any investment from the retailer.
- The suppliers depend on the retailer for reliable business but the retailer does not depend on the suppliers as many suppliers would like retailer business.
- Communication is mostly from the retailer to the supplier with the issuing of the growing programs, product specifications and their policy changes.

7.6 Certification and Compliance

The participants were asked questions on the certifications they currently operate on and are required to possess by either the retailer or the government. The FBO code was a requirement for sale at the fresh produce market and all farms and packing facilities possessed this, but it was not a requirement

for supplying the retailers. High care facility 1 did not have an FBO code as it only packages for retailer A and does not sell at the fresh produce market. Medium care 1 and high care 2 did state that they are working towards HACCP certification and will hopefully obtain it before year end. The packing facilities can obtain a health certificate from the government but it is not law or a licence to operate. If a supplier does not have a certification for their packing facility, the fresh produce market flags them as high risk and performs more tests on their produce compared to those with certifications and flagged low risk. The fresh produce market is a member of Global GAP and can access the database to check its suppliers audit history and certification status. Retailer C is also a member of Global GAP.

The retailers do not assist financially or otherwise in the obtaining the required certifications. The financial burden falls on the farmers and facility owners to obtain the certification and renew it when necessary. The farmers did state that the Global GAP certification and all its requirements for auditing was rather expensive and did affect their overall profit margins, hence those farmers who cannot afford it resort to selling their produce at the fresh produce market which does not require all these certifications and audits. Retailer C did not audit its suppliers and relied on the audit reports from Global GAP.

The results obtained from the analysis are:

- A number of certifications exist and are costly to the producers. The farms had Global GAP, the packing facilities had either HACCP or FSI.
- Government policies exist that have been explained in the literature review section.
- Certifications require renewal yearly and the participants cover their own costs.

Section C

7.7 Constraints in traceability

It was noted that different constraints affected the participants in the supply chain. The results obtained from the analysis are explained.

Time

- Information required for traceability does not accompany the product. It takes a considerable amount of time contacting the participants in the supply chain to obtain information about a product and trace source of contamination.
- The maximum residue limit and microbial test results take two weeks to a month to be obtained. The fresh vegetables have a shelf life of five days or less, hence by the time the results are obtained the produce has been consumed.
- Due to the time it takes to obtain results, the product is sold without certainty that it is free of pesticide residue and harmful pathogens as suppliers and retailers cannot wait for the results.

Liability

- The participants are cautious to share their information which is essential for traceability, as they will be found liable, in the case of contamination if they are identified as the source.
- According to some participants the responsibility of contamination always lies with the primary producer who is the farmer.
- The retailer is liable if the suppliers are not certified or do not comply with the set spray programs and residue limits, hence the retailer has to ensure compliance of all suppliers to shift liability from them. The retailer has to prove the supplier is liable.

- Obtaining certification ensures the suppliers are aware of the risks of not complying, in which case they become liable.
- The fresh produce market does not take ownership of the produce hence it is protected from liability.

Cost

- The cost of the maximum residue tests and microbial tests limits the total number of tests that can be performed by each participant. Random testing is then implemented and not all produce handled is tested, which is a requirement for full traceability that a sample of each and every product has to be tested.
- The band of the substances to be tested for is also limited, as with increase in the list of substances the cost also increases. It is a possibility that a harmful substance may be present on the produce but is not tested for. Even with an in-house laboratory the cost is still high.
- To obtain results earlier, the participants have to pay more, thus cost hinders quicker results.
- The cost of technology such as barcode readers and scanners for the implementation of traceability is a challenge as farmers might not be able to afford it.
- The cost of implementing a traceability system and resources required, and the party responsible for covering these costs.
- Certification costs are also a constraint, as one producer requires multiple certifications which need to be renewed each year so as to supply the different retailers.
- Audit costs also need to be considered as a supplier is audited by each retailer and third party certifying bodies which amounts to a considerable amount of money in one year.
- In the case of noncompliance, the supplier has to implement changes to comply and obtain certification which is again an unplanned cost.
- The in house laboratory also requires certification to operate which is an added cost.

- The cost of consumables required by the laboratory present a challenge as they limit the number of random tests that can be performed among the high volumes received.
- Labour costs are also a constraint as more employees are required to perform checks on all produce received to ensure full traceability.
- Small producers cannot afford the certification and laboratory costs which becomes prohibitive for their participation in the supply chain.

Competition

- The retailers cannot impose traceability on the farmers or packing facilities as the suppliers can choose to sell their produce at the less regulated fresh produce markets.
- The introduction of technology might also result in suppliers moving away from the retailers to fresh produce market.

Age of farmers

- The age of the farmer is a constraint as they are unable to use the technology that may be required to implement traceability.

Education of farmers

- The farmers may be unable to use computers and other technology essential to traceability.
- The farmers may not be able to understand the benefits of implementing traceability.

Legislation

- The number of certifications that exist available to suppliers are numerous and repetition of requirements that are beneficial to traceability occurs. The introduction of one certification used by all retailers or a law would be beneficial.
- The government does not want to over regulate the industry as it endangers food security and affects peoples' livelihoods.

- There is no law on including traceability information on produce labels.
- Calibration of scales and equipment is not a law but is a requirement in the implementation of full traceability.
- Retailers are more concerned with what law is and what is not, even when the latter is an important aspect of traceability they are reluctant to implement it.
- Some suppliers are reluctant to implement traceability unless the government makes it law.

Management of produce

- Loose products present a challenge with keeping traceability information attached to them during processing and when selling in retail stores.
- The participants who deal with high volumes have no system in place to avoid mixing of batches delivered on different consignments as the product packaging has no batch labels.

Consumer awareness

- The media does not report on outbreaks or contamination, hence no recorded information is available or gathered data on cases of fresh vegetables causing illness in consumers.
- The retailer has their own perceptions about the information the consumer requires and this does not avail the required information for implementation of a fully traceable supply chain.
- The retailer also believes the consumer should take comfort in the fact that the retailer followed safety and hygiene processes when procuring the fresh produce.
- Consumers do not know when to report an illness due to consumption of contaminated produce

Technology

- The lack of instant testing methods available to retailers and suppliers at affordable prices is a challenge.

- Most participants are concerned with the practicality of using technology that might require hiring and training new staff which increases costs.
- The need for easy to use systems is also important as some farmers and employees have low education levels.
- The cost of the technology itself might present a challenge in the implementation of traceability.

8. Discussion of Results

In this chapter, the results in chapter 7 are discussed. The discussion is separated into smaller sections that reference the themes that were outlined in the theoretical framework for this research.

Section A

In this section the results on evaluation of traceability are discussed in detail.

8.1 Evaluation of traceability

From the results the current state of traceability of all three retailers in this research are shown in Table 10, 11 and 12 to be partly traceable. It is evident from the comments that some suppliers do have the required aspects in place but it is not uniform throughout the supply chain. It can also be noted that no aspect was found to have no traceability with level 1 on the scale given. This can be attributed to the retailers' efforts in the fresh vegetable supply chain to introduce and improve its traceability, hence the implementation of traceability codes by the suppliers and tracing of packages as highlighted in Table 4 of product management.

Retailer A did not attain full traceability because, information on genetics, microbial and maximum residue tests was not passed upstream, tests were performed on random batches and not all produce was tested, tracking of transportation was not in real time and the produce from the fresh produce market did not always have the cold chain monitored.

Retailer B also had partial traceability. The issues affecting the state of traceability were the similar to those of retailer A and C which were, information not passed on upstream, tracking of transportation not in real time and microbial and maximum residue tests being performed on random samples and not all produce samples. The cold chain monitoring was noted to be consistent within the supply chain with all participants making use of refrigerated trucks and monitoring the temperature.

Retailer C was found to have a partly traceable supply chain. This was due to cold chain monitoring not being uniform throughout the supply chain, random testing being performed on produce, calibration not being uniform throughout the supply chain, tracking of transportation not in real time and genetic information and product history not being passed upstream. The maximum residue limit test results were passed to the retailer with the produce and the retailer did not have to perform any additional tests.

The differences in the supply chains of the three retailers in this study did not have an impact on the overall state of traceability. Retailer A and C had a complex supply chain as they operate decentralised distribution systems, this did not impact on their current state of traceability. However procurement from the fresh produce market presented a number of challenges. Retailer B required all its suppliers to have packing facilities, this limited the amount of players in their supply chain, making it more manageable as all suppliers were known and certified. All three retailers performed part of the requirements for traceability but fell short when information they recorded had to be passed on to the next participant in the supply chain.

The development of a theoretical framework to obtain the results for this research fulfilled the gap identified in the motivation in chapter 1. The framework enables the state of traceability to be measured and areas that require improvement to be identified. This will enable full traceability to be implemented and efficient supply chains in the agricultural industry.

Section B

In this section the results are discussed with reference to the five supply chain enablers that were developed for the research and form part of the theoretical framework. The enablers are essential to traceability of a supply chain.

8.2 Information Management

In the interviews conducted with the participants, it was noted that although the participants record all their processes, little and in some cases no useful information is passed on to the next partner in the supply chain as shown in Table 3. This hinders traceability as it is defined by Bollen (2009) as the movement of both product and information about that product through the supply chain. The traceability code that is passed on to packing facilities was not useful as the packers did not understand what it represented. It was also noted that no information is passed back that is useful for traceability. The usefulness was evaluated as stated in the analysis in chapter 6. The information farmers and packing facilities receive from the retailers is the growing program for the next season and new product specifications when changes have been effected, such as weight of vegetables in each package or size to be packed.

The quality of information that they record was noted to be high and very useful. This was determined using the analysis in chapter 6 to evaluate the quality of information. The FBO code obtained from the fresh produce market did not give information on processes undertaken by a particular farmer on the vegetables contained in the boxes and pockets. The farmer would have to be contacted directly and information about the farmer would be obtained from the government database. When the participants were asked how long it would take them to find all information about a particular vegetable they had grown or processed in the case of contamination, the response was from four to twenty four hours. The use of a manual system, FBO codes and traceability codes as the only reference, could be attributed to long periods searching for relevant information. The use of a market agent in the fresh produce market meant the suppliers and buyers at the market had no direct contact. This also lengthened the trace back process as information and communication had to go through the agent between buyers and suppliers.

When a retail store owner has a consumer with a complaint about a product, they firstly have to access their records using the supplier code on the label and then contact the supplier. After this the supplier requests a sell by date on the label which enables them to find the date they processed the vegetables in their facility and relay the required information back to the retailer then to the consumer. In an ideal situation the retailer would be able to give the consumer all the information about a vegetable such as who the farmer is, when it was grown, when it was harvested and date packed including all the processing done to it when requested.

The use of technology such as barcode readers and RFID tags would be useful in storage and passing of information upstream, as the produce already contain barcodes on packaging and labels for the retailers.

8.3 Product Management

The retailers issue specifications to their suppliers which govern the cleaning, grading, classification and packaging of produce. For both high care facilities and medium care 1, the produce on arrival is washed in chlorine water to remove dirt and sanitise the vegetables. For the medium care 2 and low care facilities visited, no washing was performed before packaging. Dirt was removed by wiping with a cloth when necessary. The product that is peeled and cut is also treated so that it does not change colour such as potatoes. Value adding processes are performed in the packing facilities.

The type of packaging plays an important role in traceability as it contains important information that should accompany the produce throughout the supply chain. For loose products, traceability information is lost when they reach the packing facilities and stores and are processed and emptied on to shelves. Batch mixing also occurs as processing is done and in stores as the shelves are continually filled up. The use of first in, first out and processing each batch at a time were some of the principles employed by packing facilities to ensure no batch mixing occurred. The fresh produce market did have an issue with batch mixing as the packaging had no labels to identify the different

batches received at the market. For the farms and packing facilities, it was noted that all packaging used, had a code that they recorded on their dispatch sheets. This ensured that in the event of a complaint due to faulty packaging, they could trace it back to the supplier. It was also noted that retailer B had made it mandatory for packaging traceability and it had been implemented by all its suppliers. The fresh produce market also specified the type of packaging required such as lugs, punnets, pockets and boxes specific to the type of produce, as set out in the Agriculture products standard act but did not have traceability for the packaging.

The labels contained on the packaging are also regulated by the retailers. Information on the labels may include company logo, sell by date, price, supplier code, type of vegetable and barcode. The sell by date was noted to be commonly used to trace back in the packing facilities as they could calculate backwards to the harvest and processing date thus obtaining required information for traceability. The fresh produce market had a different set of rules for labelling which stated that the packaging should contain an FBO code, grower initials, type of vegetable and/or variety and amount in weight or count. The information contained on the retailers and fresh produce market packaging did not aid full traceability. Information on processes performed on the produce and tests done was not available. For retailer A, C and the high care facility 1 who source produce at the fresh produce market, there was a gap in the information about the supplier. They all had to rely on the work of the market agent to ensure their product specifications were met, information required had been kept in supplier records and the correct government spray programs had been followed. The produce history should accompany the product at every point and is essential in obtaining a fully traceable supply chain

Mock recalls assist the supply chain to be evaluated for performance in the case of an emergency. The results show that only one farm and retailer C perform these mock recalls on fresh produce. The fresh produce market indicated that due to the lack of incidences of contamination they have stopped mock recalls on the produce.

All facilities have their own transportation from the farm to the distribution centre of the retailer after packaging. The retailers also have their own transportation from their distribution centres to the various retail stores across the country. For the farms with packing facilities the transportation did not require refrigeration as the pack houses are located on the same property and, a truck or trailer could be used. The fresh produce market did not own any trucks or provide transportation either to or from the market. Tracking of transportation trucks was varied among all participants. Medium care facility 2 and all the distribution centres had real time tracking. With full traceability, the whereabouts of the product should be known at all times, thus real time tracking is necessary.

8.4 Quality Assurance

Information that was recorded on organoleptic and external attribute checks was not uniform among all participants. This could be attributed to the production of different vegetables. None of the information recorded was passed either upstream or downstream in the supply chain. Although the schedules were different, the checks were performed at every point in the supply chain, even at the distribution centres, produce was checked before it was received.

The importance of tracking the temperature and ensuring the cold chain is important and highlighted by Bollen (2009) who states that the measurement of temperature is critical in a supply chain to ensure quality is maintained after harvesting. Maintenance of the cold chain also prolongs the shelf life. The fresh produce market did not monitor the cold chain and did not check temperature of produce on delivery. It also did not ensure the produce was loaded in to refrigerated trucks when purchased. All other participants in the research monitored the cold chain and used refrigerated transportation containing electronic temperature gauges which kept a record of the temperature of products while transporting to ensure quality and shelf life were maintained.

The farmers perform maximum residue limit tests as it a requirement of Global GAP and local GAP certification. The low, medium and high care facilities also perform the maximum residue limit tests before they process and package, but not all produce is tested as random tests are performed by both farmers and facilities. This can be noted as repetition in the case that the farmer might have performed the same tests on the produce, and had the information been passed on the tests could have been avoided, or produce not tested by the farmer would have been tested by the packing facility, to ensure all produce reaching the retailer had been tested. This result agrees with Storøy, *et al.* (2013), who states that, repetition of collecting information occurs when one passes on data that is not useful and measurements have to be retaken leading to wastage of resources. Random testing is done as independent laboratories are used which are costly and samples count as loss. The range of substances to be tested for are also limited due to cost. One can only specify the substances to be tested for in a minimum range and not everything is tested for as this increases the cost, hence some harmful substances may exist on the produce but will not be tested for. According to the information gathered during the interviews the farms and facilities set a budget for the year which is allocated to testing only, this sets the limit on the amount of tests they can perform despite their processing volumes or produce output. All farms and facilities in the research cover their own costs.

It was also noted that with all the maximum residue limit tests performed, the results were only obtained after a week. With the mushroom farm, the maximum residue test results take a month. The shelf life of agricultural produce that is to be sold fresh is not more than five days from the date harvested (Bevilacqua, *et al*. 2009), hence the results will only be obtained when the produce has been sold and consumed. This is definitely a cause for concern. However those interviewed did specify that in the event that the residue levels are above the permitted amount or they have used pesticides that are not certified, the farmer is then blacklisted. The fresh produce market has an in house laboratory for maximum residue tests, however the costs are still high due to consumables and certification required for the laboratory to operate. Even with an in house laboratory random produce is tested and this was due to high volumes of produce received. The results also take five to seven days to

obtain and this was attributed to tests done establishing quantity of pesticide residue and not presence of residue only which takes a shorter time to obtain results. If tests from the market laboratory produce results above the limit, the next consignment from the farmer or supplier is put on hold until tested and cleared.

Retailer A and B also perform maximum residue limit and microbial tests on produce delivered to their distribution centres. Retailer C does not perform maximum residue and microbial tests as the suppliers are required to send their produce results to the retailer. For produce obtained from the fresh produce market by retailer C and that supplied without test results, tests are ordered by the retailer and performed by an independent laboratory and the supplier still has to cover the cost. In this case repetition is averted and no resources are wasted, information relevant to traceability is passed on. The farmers, packing facilities and fresh produce market all use an independent laboratory to perform microbial tests. The results take between three and seven days to obtain. Earlier results on microbes and maximum residue can be obtained but at a cost.

Access to technology for independent testing for maximum residue limits, chemical analysis and microbial testing at the farms and packing facilities would lessen the load on the independent laboratory and allow suppliers to test all produce more frequently. Passing of testing results upstream would also reduce repetitive testing. This could be an affordable way if the technology could be developed within the country or imported at a reasonable price.

Calibration of scales and equipment used is a Global GAP and local GAP requirement. It was noted that a participant responded that calibration was not law but a good practice. Calibration is an essential aspect in traceability of a produce supply chain and all participants should make use of a certified company to calibrate their scales and equipment.

8.5 Buyer Supplier Relationships

It was noted that the retailers dictate their requirements to suppliers. The requirements include where to source packaging, how much of the produce they require and when, how it should be packaged, what size should be in each pack and what sustainable farming methods or practices should be employed to supply them. This is supported by Holt, *et al.* (2007) who states that suppliers have little say and retailers have technology and impose low prices and stringent conditions but the suppliers cannot complain as they fear losing retailer business. Failure to meet the requirements would lead to them taking their business elsewhere.

From the interview Retailer B has since set new requirements for their suppliers as they have introduced a new program which requires all its suppliers to recycle as much as possible. One supplier did state that the cost of installing a waste water recycling plant had been costly but they had no option as they would lose retailer business. Although they do save from the recycling they had to cover the cost themselves with no assistance from the retailer. There is no shared investment towards a common goal as all the policy changes made by the retailer require only the supplier to use their own finances with no assistance from the retailer. The suppliers cannot refuse to adopt these policy changes as they will lose retailer business which they are dependent on as their major source of income. From this, one can observe that retailers can influence adoption of new systems, decision making and traceability as suppliers have no option but to comply. This is in line with the results obtained by Souza Monteiro and Caswell, (2009), Heyder, *et al*. (2012) that retail chains are the major influence or drivers of adoption of traceability and quality assurance.

The absence of legal binding contracts also elaborates on the nature of the relationship between suppliers and retailers. The suppliers are only issued with growing programs which always protects the retailer from financially. The required amounts may increase above the set targets in the growing programs of fall below the set amounts in which case the farmer is left with a lot of surplus that they

have to sell at the fresh produce market to opportunist buyers. Failure to sell at fresh produce market leads to loss of income and wastage.

The number of farmers that are able to supply the retailers is limited due to the large volume they require, the uncertainty of their quantities due to growing programs, the ability to package produce on site and the costly certification the suppliers should possess. A large number of suppliers prefer selling their produce at the fresh produce market where there are no certifications required, no limit to quantities one can supply, no need for packing facilities, no stringent product specifications and a large number of buyers. The fresh produce market does not depend on the supplier.

It was also observed that on all farms and facilities visited, the mention of being referred by the retailer who is their main buyer led to a warm welcome. This could be attributed to ensuring a long and beneficial relationship as the participants can continue to supply the retailer. No relationship exists between the retailers in this research and the fresh produce market as they use independent market agents to procure their produce from their preferred suppliers.

8.6 Certification and Compliance

From the supply chains it was noted that Global GAP certification is a requirement for farmers to supply all three retailers. Retailer C also accepts local GAP which is an entry level certification as a supplier works towards Global GAP. The farmers did express that it was expensive and they had to cover their own costs with no assistance from the retailer. Audits are performed once a year for compliance and to renew certification by an independent auditor, and random spot checks are also performed. The high care facility for retailer A also performs spot checks on its suppliers.

The retailers do perform their own audits of the farms every year as they set their requirements that are not covered by legislation. These were noted to be strenuous on the farmers and facilities as those

that supply different retailers have to fulfil varying requirements to meet the audits. The retailers always kept introducing new terms and conditions with each audit as they improve their brands, but this is financially costly to the farmers and facilities to always adhere to. It was also noted that with varying requirements set out by the retailers and certification bodies, they have not been problems so far although instances of some saying the required improvements had not been necessary have been noted. Retailer C and fresh produce market do not perform audits on the suppliers but rely on the Global GAP database to obtain audit reports, compliance information and certification status.

The introduction of only one standard or regulation by the government or as proposed by the Consumer Goods Council of South Africa in the establishment and adoption of FSI by all retailers would assist the farmers and facilities financially by reducing number of certifications, audits required and reduce confusion, and this was a sentiment echoed by all participants in the research. It would also assist in the implementation of traceability within the whole supply chain as supported by Bosona and Gebresenbet, (2013), who state that the introduction of new legislation is a driving force in implementing traceability.

The certifications for packing facilities are not law but are numerous options and required by the retailer. Those with Food Safety Initiative (FSI) stated that they were working towards Hazard analysis critical control point (HACCP) and would hopefully obtain it in the next two months. Only the mushroom farm which supplies both retailers has HACCP and Halaal certification for the pack house and it has Global GAP for the farm. The Halaal certification is a requirement for supplying restaurants. The low care facility did not have any certification.

The supply chain enablers gave an overview of areas that were different among the retailers and also the different aspects that contributed to their levels of traceability.

Section C

In this section the constraints that have been obtained from the analysis and results are discussed in detail.

8.7 Constraints in traceability

A number of constraints were highlighted by the participants as shown in the analysis results in Table 9.

As information does not accompany the product throughout the supply chain, it takes time to access this information in case of contamination. The time it took to retrieve the required information from each and every participant in the supply chain would contribute to the recall being compromised (Piramuthu *et al.* 2013). Time is a challenge when fresh produce is concerned as it has a short shelf life and the results agree with Engelseth (2009). This was the case with maximum residue tests and microbial test results which took three to thirty days, being obtained when the produce was already sold and consumed. Retailers and suppliers did stress that they could not wait for the results as it was not feasible with the shelf life in question. If a problem was to be noted, the fresh produce market did say they would hold the next consignment from that supplier and wait for results before releasing the produce for sale.

It was noted that, according to participants in this research, liability always lay with the farmer although possibilities of contamination after the produce had left the field did exist. Participants in the supply chain were reluctant to share information about processes performed on the vegetables as this would expose them, and in the case of contamination occurring, they would be liable. This result agreed with the researches by Smith, *et al*. (2005) and Pouliot and Sumner, (2008), who state that in the United States livestock supply chain, farmers are faced with the problem that information that has been stored for traceability, may lead to them being fined or penalised for producing poor

quality products and not being compliant and are hence hesitant about its implementation. The retailers are only liable when their suppliers are not certified or noncompliant, but they have to prove it was the suppliers' fault. Certification educates farmers on areas essential to traceability and issues that may result in liability. The effects of liability are, bad reputation, lawsuits and loss of business among others.

The cost of maximum residue and microbial tests leads to retailers resorting to random testing, thus some of the produce sold and consumed is not tested, which is a traceability requirement. To obtain quicker results the cost of the tests increase resulting in retailers and suppliers waiting for the standard time. The costs of these tests also limits the number of substances that can be tested for in a particular product. This presents a problem as harmful substances on the produce may not be on the list and substances to be tested and will go unnoticed only to cause illness outbreaks in consumers. The technology purchase, installation and training, costs are also a challenge as farmers and suppliers might not afford them. The cost of implementing traceability systems, resources required also present a challenge as suppliers do not get any financial assistance from the retailers. The possession of a valid certification present a number of financial challenges to the suppliers which are, audit costs, laboratory costs for microbial and maximum residue tests and the cost of issues that may need to be resolved in the case of noncompliance after an audit to obtain renewal of certification. Having a laboratory onsite might have its advantages but the costs associated with its certification for operation and consumables required to test the produce present a challenge to traceability. The labour costs associated with traceability are also a concern, as its implementation requires employee training and hiring of skilled workforce which the suppliers are unable to afford. These results agree with Popper (2007) who states that traceability implementation increases costs due to increase in labour and technology required. Cost can be noted as the major constraint to implementing traceability in the fresh produce supply chain.

The presence of competition also presents a challenge within the supply chain. If the retailers were to implement very stringent conditions on their suppliers, the suppliers could choose to sell at the fresh produce market, hence the implementation of traceability should ensure all parties involved see the need and benefit of a fully traceable supply chain. Issues such as adoption of technology to implement traceability may also influence suppliers to move away from the retailers to the fresh produce markets.

Education was also highlighted as a constraint with regards to implementing technology as farmers are unable to make use of the technology due to lack of education and training as well as their advanced age. Farmer education also limits the ability to understand the benefits of traceability. These results agree with the studies in the literature review by Burton, *et al*. (2003), Tey and Brindal, (2012) and Genius, *et al.* (2006) who highlighted that adoption was affected by farmer lifestyle, education and economic benefits.

Legislation plays an important role in driving traceability adoption and implementation. The number of certifications that exist present a challenge to suppliers as retailers have different preferences to the certifications on the market. The retailers are more concerned with adhering to the laws and overlooking important aspects essential to traceability such as calibration and inclusion of traceability information on labels which are not law. Suppliers are also reluctant to implement traceability unless it is made into law. The government on the other hand does not want to over regulate the fresh produce industry as it might affect food security and income of small farmers. The introduction of one certification to cover all retailers and law to encourage adoption of traceability systems would be a step in the right direction.

The management of the product was also pointed out as a constraint as loose products present a challenge in maintaining the records and information on traceability constantly accompanying them during processing and when selling in stores. The mixing of batches becomes an issue when the

information is not present to accompany the produce and the different batches are not clearly labelled.

Consumer awareness is also a challenge, as the retailer stated that there was no need to possess all the information about farming activities as this was not essential to the customers. The retailers have their own perceptions of what consumers want and think about their procurement processes when it comes to fresh produce. The lack of recorded incidences of contamination was also highlighted, as information on such cases is not recorded and published and the consumers and media do not report it. Consumer education is also a challenge as reports on illness due to consuming contaminated food have not been recorded.

Technology that produces instant results would benefit the participants as it is currently a challenge as they rely on laboratories which produce results after sale of produce. The technology would have to be affordable and easy to use to avoid increase of costs due to training employees and farmers. Availability of technology within South Africa would benefit the participants as training on usage can be arranged and repair and maintenance is readily available.

The constraints highlighted in this section are areas that could be addressed and would assist with the state of traceability in the overall supply chain.

8.8 Summary

The results from the interviews and observations show the current state of traceability in the fresh vegetable supply chain. The five enablers of a supply chain showed the shortcomings of the current state. The differences in the supply chains of the retailers in this research had no impact on the state of traceability. As can be noted in the results in chapter 7, all three retailers are partly traceable. A

fully traceable supply chain would fulfil all six aspects outlined in section 6.1 on the evaluation of traceability.

With regards to information management, the participants do record information that is accurate, consistent and useful but do not pass it on to others. All information on product management processes, quality assurance checks, laboratory tests and certifications should accompany the produce at all times in the supply chain. Technology use is limited to computers for input and storage of information. Adoption of technology such as barcodes and RFID tags would assist in making information sharing easier.

The farmers, fresh produce market and distribution centres did not perform any processes on the vegetables such as washing and cutting as did the packing facilities. The participants who had trucks for transportation tracked their vehicles although not all of them was in real time. The type of packaging used was governed by the retailer of the Agriculture products standard act.

The differences in the vegetables grown and processed by the suppliers accounts for the differences in quality checks performed. Retailer C is the only participant who does not perform maximum residue and microbial tests and requires the suppliers to submit their own. Cold chain monitoring was variable along the supply chain, as was the use of refrigerated trucks. The test results for pesticide residue and microbes took between three and thirty days to be obtained and not all produce sold was tested. Essential aspects such as calibration of scales were not valued.

The suppliers do not have legal binding contracts with the retailers and are issued with growing programs. The suppliers depend on retailer business but do not get any investment from the retailer. The retailer also influences the decision making process. Opportunistic buying is done from the fresh produce market through a market agent. A number of certifications exist and the three retailers have different certification requirements for the participants. The certifications require renewal and audits annually, which cost a lot of money to the suppliers.

The constraints that were faced in the implementation of traceability were, time, liability, cost, competition, age of farmers, education of farmers, legislation, management of produce, consumer awareness and technology. Cost was noted to be the major constraint as it affected the overall implementation of full traceability in the supply chain.

9. Conclusion

The first objective of this research was to determine the level of traceability in South Africa in fresh vegetables and this objective was met. Currently partial traceability does exist within the supply chain. The traceability was deemed partial as shown on the evaluation Tables 10, 11 and 12, because the six aspects which are to be implemented at every point within the supply chain to ensure full traceability were not fulfilled in this research. Areas that the retailers had to address to ensure full traceability were highlighted in the evaluation tables. The study also explored the five supply chain enablers and their importance to traceability. The five supply chain enablers were developed for this research and make up part of the theoretical framework used within the research. Information was recorded at every stage in the supply chain that was useful to traceability and was not passed upstream or downstream. The produce had packaging materials that could be traced back to their suppliers in the case of complaints. Although quality checks were performed on the produce and microbial, residue limit and chemical tests were done as required by the different certifications, the information had to accompany the product to ensure full traceability. The differences in the three retailers' supply chains were highlighted and areas that needed improvement with regards to supply chain enablers to ensure full traceability.

The second objective was to look at the constraints that the participants in the supply chain face in the implementation of traceability. The constraints that were a result of the content analysis of the interview transcripts are 1) Time, 2) Liability, 3) Cost, 4) Competition, 5) Age of farmers, 6) Education of farmers, 7) Technology, 8) Legislation, 9) Management of produce and 10) Consumer awareness.

The third objective was to establish the implications of the current state of traceability. The constraints that were obtained from the results are major contributors to the implications of the current state of traceability. The implications can be stated as a) due to the time it takes to obtain maximum residue, chemical analysis and microbial tests results, contaminated produce may reach consumers and cause

outbreaks with the source being difficult to trace, leading to losing consumer trust and facing liability charges, b) in the case of an outbreak occurring, recalls would take longer as information is scattered and gathering it together to trace back produce would take time, c) liability was also increased, in the case of contamination when no traceability systems and certified processing of fresh vegetables exist, d) contamination could occur at any point during transportation as the physical location of the product at all times was not known for those suppliers without real time transportation tracking systems, and e) the use of measurement instruments that were not calibrated with reference to a standard by some of the suppliers meant their scales and thermometers among other instruments could be taking wrong readings, thus the consumer may purchase produce that has inaccurate weight, hence either the supplier or consumer is at a loss.

This research fulfils the gap that was identified in the motivation in chapter 1 which is the lack of a theoretical framework to measure the state of traceability. A theoretical framework is an important tool to study traceability and was developed and tested, which can be used to measure the state of traceability of a supply chain and areas that need work can be identified and improved. The five supply chain enablers which form part of the theoretical framework were also identified and developed for this research.

The implications of this research are:

- A theoretical framework has been developed and tested and the agriculture industry can utilise it to measure the state of traceability for different supply chains.
- Five supply chain enablers have been identified and developed, that aid in the evaluation of a supply chain as well as measurement of traceability, which are specific to the agriculture industry.
- The retailers and participants in this study can improve their supply chain management and establish full traceability by addressing the issues raised by the research.

- The costs that have been shown to be major constraints can be alleviated by retailers establishing one certification and test results being passed upstream in the supply chain.
- In case of contamination or disease outbreak due to fresh produce, the current supply chain will take a considerable amount of time to establish the source and this research will allow retailers to ensure timeous location of contamination can be made.
- The issue of liability, which most retailers believe lies with the producer, with full traceability, the research shows any participant can be liable if contamination occurs when they are in possession of the produce, hence food safety and hygiene should be implemented and basic training and certification obtained.

10. Recommendations

Further research in legislation that exists in the agriculture industry that could benefit traceability is required. The compliance to the legislation would also need to be investigated. A number of policies do exist as covered in the literature review of this research.

The Fresh produce market would benefit from research on their supply chain management, implementation of traceability or improvement on their current state to attain full traceability. This would assist farmers who are not able to supply the retailers as their produce does not have the required certification and is not fully traceable.

A consumer survey is also recommended to establish the kind of information consumers require from their retailers about produce they purchase. This survey can also assist in the trimming down of information that is passed on from one link to the next to ensure quality, usefulness and relevance.

Development of technology that produces quick results, is easy to use and affordable to members of the supply chain would aid the agricultural industry in implementing full traceability.

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12. Appendix

12.1 Interview Questions

Retail Managers

1. What information do you receive from the suppliers?
2. How do you record and store it?
3. Do you perform independent quality checks, if so how many and at what intervals?
4. What information is recorded in these checks and how is it stored?
5. What information do you pass on to the retail chains and suppliers?
6. How do you package and transport the produce?
7. How do you label the packages and record the information?
8. What laws and certification govern your suppliers and quality assurance division?
9. What relationship exists between the retail chains and the suppliers?
10. Who is liable in the case of contamination?
11. What constraints do you face with regards to traceability?

Farm Managers

1. What information do you record and how do you store it?
2. How much of the information do you pass on to others in the supply chain?
3. What quality checks do you perform?
4. How do you transport and track your produce?
5. How is the produce packaged and labelled?

6. What certification do you require to supply a retail chain?
7. Are there any other laws you have to abide by in your production or transportation?
8. What kind of relationship exists between you and the retailer?
9. Who is liable in the case of contamination?
10. What constraints do you face with regards to traceability?

Quality Assurance

1. How do you perform quality checks?
2. How many checks are performed?
3. What information is recorded in these checks?
4. What happens when the produce does not meet the quality standard?
5. What other tests, if any are performed on the produce?
6. What is the overall cost on the checks and who covers them?
7. What constraints do you face with regards to traceability?

Packing Facility Managers

1. Where do you source your produce?
2. What checks, quality or other do you perform?
3. What laws or certification govern your sourcing and operation?
4. What information do you receive from the suppliers?
5. What information do you record on the processes done?
6. What information do you pass on to the retailers and suppliers?
7. How do you label and package the produce?
8. How is the information stored from labelling and packaging?
9. How is the product transported and tracked?

10. What relationship exists between the facility, suppliers and retailers?
11. Who is liable in the case of contamination?
12. How long does it take to access the history of a product?
13. What constraints do you face with regards to traceability?

Department of Agriculture Forestry and Fisheries

1. a) What policies exist with regards to traceability of fresh vegetables sold within the country?

   b) How are these policies enforced?
2. What policies govern the sale of fresh vegetables in retail stores?
3. What relationship exists between the government and retailers?
4. Does the government provide any certification for packing facilities to operate?
5. How does the government regulate the operation of the packing facilities?
6. a) What plans are in place in the case of food contamination or disease outbreak due to consumption of fresh produce?

   b) Who is liable in the case of contamination?
7. Is there any data on cases of outbreaks that have occurred in the past due to food contamination?
8. What constraints are faced by the government in implementing and maintaining traceability of fresh produce?
9. In your opinion, do the current standards that exist aid the traceability of fresh vegetables?
10. Are there any policies the government is working on with regards to traceability of fresh produce?