A quantitative and qualitative study of retail food waste in New Zealand

Francesca Goodman-Smith

A thesis submitted in partial fulfilment

of the requirements for the degree of

Master of Science

at the University of Otago, Dunedin

New Zealand

January 2018

Abstract

Background: With an estimated one-third of the global food supply going to waste, it is crucial that the quantity of wasted food is reduced. Target 12.3 of the United Nations Sustainable Development Goals aims to halve per capita global food waste at retail and household levels by 2030. Three steps have been suggested to achieve this goal: target, measure, and act. Measurement of food waste is necessary in understanding the scale of the problem and to identify areas for intervention. Little is known about the quantity of food wasted in the retail sector, and there is no publicly available data for New Zealand. In order to 'act', barriers to food waste reduction need to be overcome. Gaining insight into what motivates retail staff to reduce food waste and the barriers that prevent reduction is an important step to inform targeted interventions that will reduce retail food waste.

Objective: To measure the quantity of retail food waste in New Zealand, to identify key motivators and barriers for retail food waste reduction, and to draw comparisons to data on food waste collected by New Zealand retailers.

Design: A quantitative and qualitative study of 16 supermarkets in four urban centres. The general study design followed a three-component methodology used by the Waste and Resources Action Programme (WRAP) in the United Kingdom to measure retail food waste, which included: onsite food waste audits, semi-structured interviews, and analysis of existing food waste data.

Method: Onsite food waste audits were carried out in both Countdown (n=8) and Foodstuffs (n=8) supermarkets located in Auckland, Wellington, Christchurch and Dunedin. Food waste generated over a 24-hour period in each store was sorted, weighed

and recorded. Semi-structured interviews were carried out with key retail staff at each supermarket (n=16) and thematic analysis using the NVivo qualitative analysis software was conducted to identify usual waste behaviours, motivators, and barriers associated with in-store food waste reduction. Data provided by each retail body was also used to understand usual food waste patterns.

Results: Complete quantitative data was obtained from 11 of the 16 supermarkets audited. Estimates for retail food waste in New Zealand amounted to 13 kg/capita/year for all food waste and diverted product (i.e. all food not sold or utilised at a retail level including food waste and food donated to charities and as animal feed), 5 kg/capita/year for food waste only (i.e. food waste directed to landfill, protein reprocessing and compost) and 3 kg/capita/year for food waste sent to landfill. A total of 77% of all discarded food measured in onsite audits was diverted from landfill (i.e. donated to food rescue charities, as animal feed, protein reprocessing and compost). Of this, approximately 46% was donated for animal feed, 15% was donated to food rescue organisations, 14% was directed to protein reprocessing, and 1% was composted. Of the 23% of food waste sent to landfill, the largest contributors were dairy products, bakery, and meat and fish. Of all food measured in onsite audits, fresh vegetables accounted for 27% of discarded product, followed by bakery (23%), meat and fish (19%), fresh fruit (17%), dairy (6%), staple foods (i.e. household grocery items such as oats, pasta, flour and tinned foods) (3%), non-dairy drinks (2%), and all other remaining food categories (2%). Qualitative interviews with 16 retail staff identified the following motivators for encouraging food waste reduction: protecting the environment; making profit; caring for the community; and doing the ‘right’ thing. The key barriers identified to food waste reduction included: training and education; food safety concerns; quality standards; waste diversion avenues and capacity; and lack of available resources. Comparisons between audit data and food

waste data recorded by retailers were only possible for one store; audit data and store reported data had similar total quantities of food waste. However, due to the different methods of collecting food waste and missing data it was not possible to draw these comparisons for other audited stores.

Conclusions: This study provides baseline data for the quantity of retail food waste produced in New Zealand. The effectiveness of future food waste reduction initiatives in the retail sector can be measured against this baseline data. Waste reduction initiatives should focus on reducing food waste at the source, as well as diverting dairy, bakery, and meat and fish away from landfill. Successful initiatives are likely to incorporate the environmental protection and profit driven motivators for food waste reduction identified by retail staff, and overcome the significant barrier of training and education.

Preface

The candidate approached Associate Professor Sheila Skeaff (Department of Human Nutrition, University of Otago) and Dr Miranda Mirosa (Department of Food Science, University of Otago) in 2015 with the desire to undertake research in the area of food sustainability, who jointly supervised the candidate. In early 2016, this team devised a study that aimed to collect quantitative and qualitative baseline data for retail food waste in New Zealand. The project supervisors supported the candidate from conception of the thesis topic through to thesis completion.

A review of the literature on the topic of retail food waste was undertaken, for which the candidate was responsible. The candidate wrote and submitted an application for Category B ethical approval, and presented a research proposal to the Department of Human Nutrition.

Under the guidance of the supervisors, the candidate was responsible for:

- recruiting and communicating with nominated representatives from Countdown and Foodstuffs;
- ongoing correspondence with store representatives;
- recruitment of stores and volunteers to assist with food waste audits;
- confidentiality agreements prepared by University of Otago legal advisers, and subsequent signing of documents by representatives from the retail bodies and volunteers;
- development of data collection tools and interview questions;
- onsite store audits with the assistance of volunteers and retail staff, including the measurement of all food waste and qualitative interviews;

- data entry and analysis of quantitative data;
- transcription of interviews, development of a coding structure for interviews, and thematic analysis of qualitative data.

During the preparation of this thesis, the results were presented on two occasions:

1. A sustainable future: The role of supermarket food waste was presented at the WasteMINZ (Waste Management Institute of New Zealand) Annual Conference, Hamilton, New Zealand 6th – 9th November 2017.
2. A qualitative and quantitative exploration of retail food waste in New Zealand was presented in the thesis results seminar, Department of Human Nutrition, University of Otago – 22nd November 2017.

Acknowledgements

There are many people who I owe a great amount of gratitude to for their support and guidance throughout my master's journey.

To my supervisors, Miranda and Sheila. I cannot thank you enough for your enthusiasm and inspiration. It has been a privilege working on this exciting and challenging project with you both. Miranda, thank you for all the amazing opportunities you have provided me with to gain work experience while completing my master's. I cannot thank you enough for challenging me to work to my full potential. Sheila, thank you for reading countless drafts and supporting me over the finish line. Your feedback has been invaluable.

Thank you to the retail representatives and the staff at the stores who participated in this study. It was an absolute pleasure to work with you on this project. Hopefully the results will help you work towards your waste reduction goals. Your willingness to assist and the insights provided were very much appreciated. I would also like to thank my amazing volunteers for taking on the not so glamorous task of dumpster diving. Your patience and enthusiasm was much appreciated and made the experience pleasurable. A special thank you to Maddie for giving up an entire day and evening to conduct two huge audits with me, I could not have done it without you. Thank you so much for all your moral support throughout this process, you are one in a million. I would also like to thank Jenny Marshall, your advice throughout the project was invaluable.

To my parents, Phil and Caterina. Thank you for your constant support and words of wisdom. You have listened to me during challenging times and celebrated the successes with me. This task would have seemed insurmountable without having you both by my side. Dad, thank you for inspiring me to work on something I am truly passionate about

and that has real meaning. You have always encouraged me to take on challenges, and this most certainly was one of them. Mum, thank you for being the most amazing support person I could ever ask for. You always know what to say when things aren't quite going right, and help me to think of solutions. Andrea, thank you so much for being there for me since day one, I am very lucky to have such a caring and supportive Aunty. Sheila and Bill, thank you for all your support throughout my university journey. I hope I have done you proud undertaking research in the area of sustainability; a topic close to our hearts. Thank you for keeping me updated with news clipping on food waste from the UK, keep being the passionate people you are.

To my friends and flatmates, especially Mads, Daina, Katie and Gen. Thank you so much for listening to my rants and encouraging me to keep going. I can't imagine going through university without you, thank you for being there for the hard times and the best times. I am so lucky to have you in my life.

Lara and Debs; the baby master's. You guys have made the last two years so memorable. I cannot imagine having undertaken this massive task with anyone else. We have really been through it all together. Thank you for everything, the crazy, the tears, and laughs. Thank you to the staff of the Department of Human Nutrition for housing me throughout my master's. I have loved being a part of the Department; the dress ups, the morning tea's, and the quizzes. A special thank you to Lisa Daniels and Rachel Brown for your friendship and support, and to Penny Field for your mentoring.

Taz, I don't even know where to begin. You have been the most amazing cheerleader for me over the last two years. You helped me to keep going and reminded me of what is really important. I am very excited for the next chapter of our lives, and feel very lucky to have shared our university experience together. A special thank you to Anne-Marie, Mike, Summer, and Christian for welcoming me into you family and for all your support.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

EU 28	28 Member States of the European Union
FAO	Food and Agriculture Organisation
FUSIONS	European Union Fusions
SDG	Sustainable Development Goal
US	United States of America
UK	United Kingdom
WasteMINZ	Waste Minimisation Institute of New Zealand
WRAP	Waste and Resources Action Programme

1 Introduction

The Food and Agriculture Organisation (FAO) of the United Nations estimate that one third of all global food production is wasted. This waste has significant social, environmental and economic implications (1). A social consequence connected to food waste is food insecurity (i.e. limited access to adequate nutrition). This is a major global issue with one in nine people experiencing inadequate access to food (2). Food loss and waste impacts on food availability, accessibility, and security (1). Environmental consequences of food waste include the loss of resources such as water, land, and energy. Global food waste and losses consume one-quarter of the world's water used for agricultural purposes per annum (2). The decomposition of food in landfills also leads to the emission of greenhouse gases, of which 8% of total emissions are attributable to global food waste per annum (3). In terms of economic impacts, wasted food world-wide amounts to approximately USD 940 billion dollars of financial losses per year (2).

Following on from the United Nations Millennium Development Goals, 17 Sustainable Development Goals (SDG) were established to work towards a fairer, more environmentally friendly future (4). At the United Nations General Assembly in 2015, 193 nations (4), including New Zealand (5), committed to tackling these goals (6). Goal 12 focusses on responsible consumption and production. The SDG target 12.3 is the globally recognised goal to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" (6). This target is supported by a collaborative group known as Champions 12.3, encompassing representatives from government, business, research institutes, international organisations, farmer groups, and civil society from across the globe

dedicated to achieving this target (7). A three-step process was set out by the Champions 12.3 to work towards achieving this goal, these steps are; target, measure, act (7).

In developed countries, food waste is greatest at each end of the food supply chain, with an estimated 17% of total food waste occurring during production, and 61% at the consumption end of the spectrum (8). Globally, retail food waste is estimated to be approximately 5% of total food waste in developed nations, and is an under-researched stage of the food supply chain (8). The relatively small proportion that the retail sector contributes to total food waste (i.e. <10%) and the commercial sensitivity of this data to retailers may explain the limited literature in this area (9). Although the retail sector makes a smaller contribution to total global retail food waste, the absolute quantity of food wasted in this sector is significant (9). The positioning of retailers within the food supply chain enables retailers to influence the amount and type of food waste produced upstream at a manufacturing level and downstream at a household level. Retailers play a crucial role in reducing not only their own food waste, but also food waste across the supply chain (1,6).

The collection of quantitative and qualitative data on retail food waste is essential to identify specific areas and ways to target retail food waste reduction and to monitor the effectiveness of reduction measures to address the 'measure' and 'act' steps of target 12.3 (7). However, no publicly available quantitative data on retail food waste are available in a New Zealand context to date. In contrast, research has been undertaken to quantify household food waste in New Zealand over 2014 and 2015 (10). This study aims to generate quantitative baseline data for retail food waste in New Zealand and compare this to existing data to address the 'measure' step of the three-step process towards achieving SDG target 12.3. This study also intends to assess key motivators and barriers to retail food waste reduction in order to inform future initiatives that 'act' to reduce retail waste.

2 Literature review

2.1 Introduction

Retail food waste is an area that has received little specific focus in terms of academic literature despite increased attention on this sector to responsibly deal with food waste. Both quantitative and qualitative baseline data are essential to measure the scale of food waste in the retail sector. This data is needed to inform targeted action and monitor the efficacy of waste reduction measures overtime.

This literature review aims to:

1. Define food waste (Section 2.2).
2. Review literature on food waste across the supply chain (Section 2.3).
3. Describe quantitative methods used to assess retail food waste (Section 2.4 and Section 2.5).
4. Describe qualitative methods used to assess retail food waste (Section 2.6).
5. Review food waste literature in a New Zealand context (Section 2.7 and Section 2.8).

2.1.1 Literature search strategies

Literature searches were conducted to October 2017 using Scopus, Centre of Agriculture and Biosciences International (CABI), Google Scholar, and the World Wide Web. Only articles published in English were included. **Table 2.1** outlines the search terms used to identify relevant articles. Articles were also identified from searching the reference lists of papers.

Table 2.1 Terms used in the literature search for this review

Search terms used for section 2.2: Defining food waste
1. "Food waste"
2. "Edible food waste"
3. "Inedible food waste"
4. "Definition"
5. 1 AND 4[1]
6. 2 AND 4
7. 3 AND 4
Search terms used for section 2.3: Food waste across the food supply chain
1. "Food waste"
2. "Food supply chain"
3. "National"
4. 1 AND 2
5. 1 AND 3
6. Food and Agricultural Organisation
Search terms used for section 2.4: Quantitative methods to assess retail food waste
1. "Retail food waste"
2. "Supermarket food waste"
3. "Grocery food waste"
4. "Quantify"
5. 1 AND 4
6. 2 AND 4
7. 3 AND 4
8. Waste and Resource Action Programme (WRAP)

[1]Papers identified by bolded terms were used in the literature review

Table 2.1 cont. Terms used in the literature search for this review

Search terms used for section 2.5: Standard protocol for quantifying food waste
1. "Food waste"
2. "Quantification"
3. "Protocol"
4. 1 AND 2 AND 3
5. Audit
6. 1 AND 5
Search terms used for section 2.6: Qualitative methods to assess retail food waste
1. "Qualitative"
2. "Food waste"
3. "Retail"
4. "Interviews"
5. 1 AND 2 AND 3
6. 2 AND 3 AND 4
7. Motivators barriers food waste reduction
Search terms used for section 2.7: Food waste in New Zealand
1. "Food waste"
2. "New Zealand"
3. 1 AND 2
4. **"Food waste in New Zealand"**
Search terms used for section 2.8: Retail food waste in New Zealand
1. "Countdown"
2. "Foodstuffs"
3. "Food waste"
4. 1 AND 3
5. 2 AND 3
6. "Report"
7. **1 AND 6**

[1]Papers identified by bolded terms were used in the literature review

Overall 47 relevant pieces of literature including a mixture of academic journal articles and grey literature were reviewed to gain insight into food waste across the entire food supply chain, and in particular retail food waste.

2.2 Defining food waste

In the literature, the terms “food waste” and “food loss” are often used interchangeably. However, food waste is considered to be waste of food that was edible at some point in time, but has been intentionally discarded or allowed to spoil due to negligence (8). Food loss is food that is unintentionally lost due to spoilage, spillage and abnormal reductions in quality (8). Typically, food waste is considered to occur in the retail and consumption stages of the supply chain, and food loss is considered to occur in production, handling and storage, and processing and packaging stages of the food supply chain (8).

“Avoidable” or “edible” food waste and “unavoidable” or “inedible” food waste are often used interchangeably in the literature as well. Emerging definitions are beginning to favour the classification of food waste as edible and inedible, rather than avoidable and unavoidable (11). For a summary of definitions used in this thesis refer to Table 2.2.

Table 2.2 List of common definitions for terms used in this thesis

Term	Definition
Retail sector	Supermarkets (excluding convenience stores).
Food supply chain	The food supply chain is the connected series of activities used to produce, process, distribute and consume food (11).
Food waste	Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea) (11).
Edible food waste	Food waste which was, at some point prior to disposal, fit for human consumption; includes both avoidable food waste (e.g. slices of bread, apples, meat) and possibly avoidable food waste (e.g. bread crust, potato skins) (12).
Inedible food waste	Food waste arising from food preparation that was not at any point edible (e.g. bones, egg shells, pineapple skins); inedible food waste is considered unavoidable food waste (12).
Avoidable food waste	Food and drink thrown away that was, at some point prior to disposal, edible (e.g. slice of bread, apples, meat) (13).
Possibly avoidable food waste	Food and drink that some people eat and others do not (e.g. bread crusts), or that can be eaten when a food is prepared in one way but not in another (e.g. potato skins) (13).
Unavoidable food waste	Waste arising from food or drink preparation that is not, and has not been, edible under normal circumstances (e.g. meat bones, egg shells, pineapple skin, tea bags) (13).
Protein reprocessing	The recycling of animal by-product (bone, fat, and meat scraps) fit for, but not intended for human consumption, into valuable commodities (i.e. fertiliser, pet feed) (14).
Use by date	The last date recommended for the use of the product from a food safety perspective (8).
Best before date	Recommends the date by when to consume the product in order to experience peak flavour and quality. It does not pertain to the safety of the product (8).
Retail food waste	Food that prematurely exits the food supply chain (landfill, compost, protein reprocessing).
Retail food diversion	Food that does not serve its original purpose, to be sold to customers, but remains within the food supply chain (food donation and animal feed).
Food product	Wasted or diverted product that was intended to be sold.
Food trimmings	Wasted product that was not intended for human consumption (e.g. trimmings).

The definitions for food waste presented in this review can be divided into two major categories: those that consider only the edible component of food to be classified as food waste (11, 8,15, 16) and those that encompass both edible and inedible components in their definition (11, 9, 17-20).

In 2011, Gustavsson et al. defined food waste as only the edible components of food that were initially intended for human consumption but prematurely exit the food supply chain (1). This definition does not encompass 'inedible' portions of food waste. Similarly, the World Resources Institute (WRI) states that "'Food waste refers to food that is of good quality and fit for human consumption but that does not get consumed because it is discarded - either before or after it spoils" (8). By this definition, food is considered waste if it is then utilised for animal feed or bio-energy purposes. In both definitions the 'inedible' components of food are not considered.

Conversely, the definition of food waste employed in 2012 by Beretta et al. categorised waste into three groups; avoidable, possibly avoidable, and unavoidable food waste (17). Avoidable waste was edible at some point prior to disposal e.g. expired products. Possibly avoidable food waste is waste viewed as edible by some individuals, but not by others e.g. vegetable peels. Unavoidable food waste is food that is commonly considered as inedible e.g. coffee grounds and onion skins. 'Inedible' components are encompassed in this definition under the category of 'unavoidable waste' (17).

European Union Fusions (FUSIONS) is a collaborative group of 21 international organisations including the Food and Agriculture Organisation (FAO), the Waste and Resource Action Programme (WRAP) and the National Research Institute on Agronomy (INRA), with a collective interest in food waste (11). In 2014, they created a definition of

food waste designed to harmonise earlier definitions used within the EU28 (28 countries within the EU). This cohesive definition states that "Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)" (11). In contrast to other definitions of food waste, the FUSIONS definition is designed to encompass what some considered as inedible portions of food (i.e. skin, bones, spent grain and coffee grounds). The inclusion of inedible portions of food waste is a change that responds to emerging ideas on the use of these byproducts to create new food products, for example the use of vegetable fibre as a binding agent in new food products (11). The definition is designed to support efficient use of resources and sustainable food systems by encouraging all food to remain within the supply chain and be fed to humans, as well as supporting changing perceptions about what is edible and what is not (11).

Debate also exists around the destination of unused food, and whether the product is then classified as waste or not. Some definitions include food that is sent to animal feed as food waste (1, 8,13, 16, 17, 19, 20), others do not consider this destination as food waste, because the animals will eventually be fed to humans (11, 18). It is common practice for food that is donated for human consumption to be excluded from estimates of food waste (11, 5, 8,13, 15-20).

The definitions presented in Table 2.3 display the different aspects of food waste encompassed in prior definitions and their consideration for the different components of food waste. For this thesis, the FUSIONS definition of food waste will be used. However, it is important to acknowledge that the literature presented in this review may have used other definitions of food waste.

Table 2.3 Food waste definitions identified in the literature review

Date	First author	Location	Title	Food waste definitions	Comparison to FUSIONS[1]
1981	FAO (15)	Rome,Italy (Headquarters)	Food loss prevention in perishable crops.	Edible material intended for human consumption, arising at any point in the food supply chain (FSC) that is instead discarded, lost, degraded or consumed by pests.	FAO definition encompasses only edible portions of food intended for human consumption which are wasted. FUSIONS includes inedible components of food waste.
2004	Smil (19)	Canada	Improving efficiency and reducing waste in our food system.	As per FAO definition, but including over-nutrition—the gap between the energy value of consumed food per capita and the energy value of food needed per capita. By-products and food fed to animals are also included in this definition.	This definition is similar to the FUSIONS definition as it includes components of 'inedible' food waste i.e. by-products. However, the definition also includes over-nutrition and food fed to animals, which are not included in the FUSIONS definition.
2009	Stuart (20)	United Kingdom (UK)	Waste, uncovering the global food scandal.	As per FAO definition, but including edible material that is intentionally fed to animals or is a by-product of food processing diverted away from human consumption.	This definition is similar to the FUSIONS definition as it includes components of 'inedible' food waste i.e. by-products. However, food directed to animals is counted as food waste.
2010	Parfitt et al. (9)	UK	Food waste within food supply chains: quantification and potential for change to 2050.	Food waste is defined as outputs of agricultural production that are explicitly for human consumption, that are not consumed by humans. (Parfitt et al. take into account the three aforementioned definitions).	This definition is similar to the FUSIONS definition as it encompasses all food which was initially intended for human consumption, edible and inedible. However, food diverted to animal feed is considered as food waste.

[1] **FUSIONS definition of food waste:** Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (11)

Table 2.3 cont. Food waste definitions identified in the literature review

Date	First author	Location	Title	Food waste definitions	Comparison to FUSIONS[1]
2010	Bloom (16)	United States (US)	American Wasteland.	When an edible item is lost due to these processes, food waste occurs. From this perspective, food waste only concerns edible items, and it is directly linked to human action or inaction.	This definition encompasses only edible portions of food intended for human consumption which are wasted, contrary to the FUSIONS definition.
2011	Gustavsson et al. (1)	Germany	Global food losses and food waste. Extent, causes and prevention.	Edible food which was intended for human consumption, but prematurely exits the food supply chain.	Only edible components are considered as food waste in this definition, and animal feed is considered food waste, which is not in line with the FUSIONS definition.
2013	Beretta et al. (17)	Switzerland	Quantifying food losses and the potential for reduction in Switzerland	Food originally intended for human consumption but then directed to non-food use or waste disposal. Including: avoidable, possibly avoidable and unavoidable food waste.	As per FUSIONS, Beretta et al. include inedible components in their definition, under the category of 'unavoidable' food waste. However, food directed to animal feed is considered as waste.
2013	World Resources Institute (WRI) (8)	US	Reducing food losses and waste	Food that is of good quality and fit for human consumption but that does not get consumed because it is discarded—either before or after it spoils.	This definition differs from the FUSIONS definition as it focuses on edible components. Also, food used for animal feed and bioenergy is considered as waste.
2016	Waste and Resources Action Programme (WRAP) (18)	UK	Quantification of food surplus, waste and related materials in the grocery supply chain	Any food, including inedible parts of food, removed from the food supply chain to be recovered or disposed of – that is, it contains both material that may be, or has the potential to be edible plus the inedible fractions associated with food.	The definition is consistent with the principles outlined in the FUSIONS definition of food waste, including edible and inedible components of food and also excluding animal feed from being considered as food waste.

[1] **FUSIONS definition of food waste:** Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (11)

In 2013, the Waste and Resources Action Programme (WRAP) in the UK published a food waste hierarchy (21). Figure 2.1 presents this hierarchy adapted for a New Zealand retail setting by the candidate with the addition of a column containing retail examples for New Zealand.

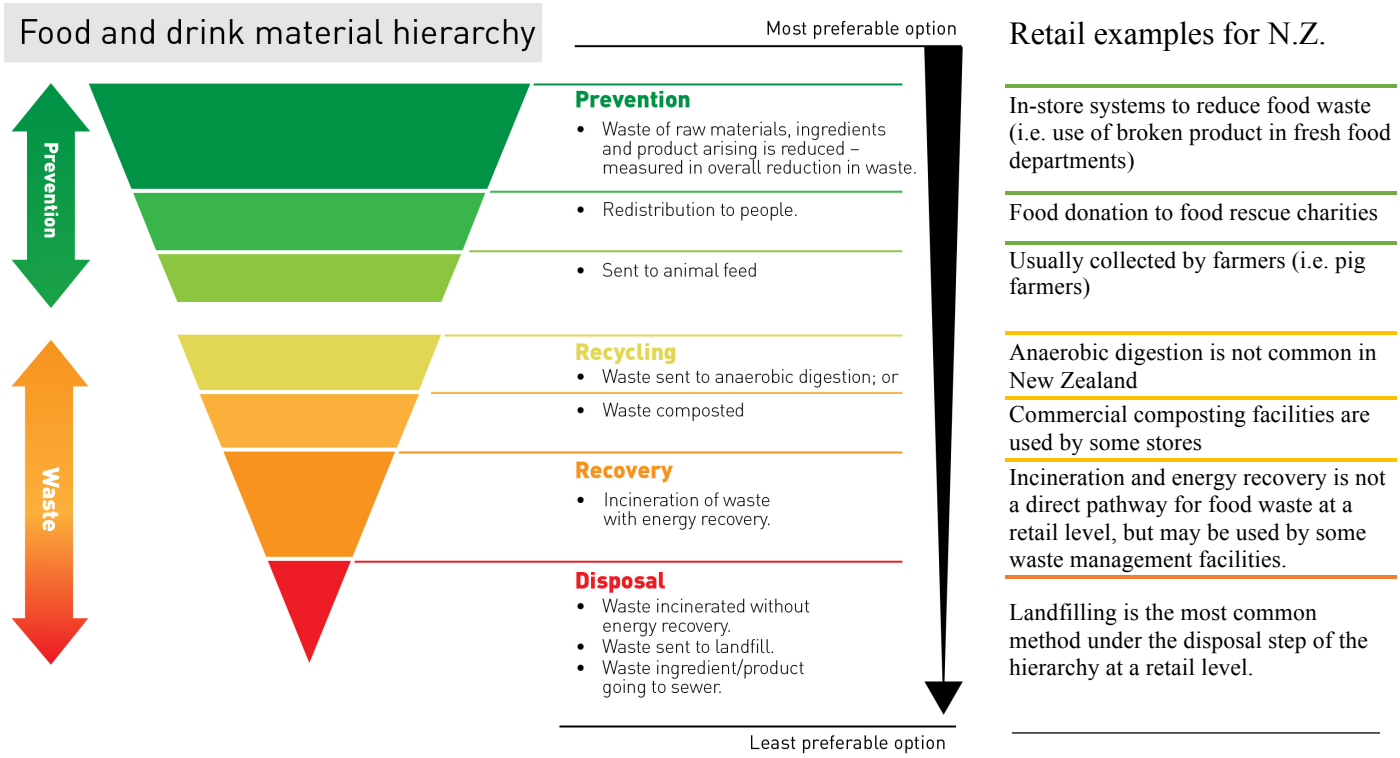


Figure 2.1 Food waste hierarchy

The top section of Figure 2.1 pictured in green is the prevention aspect of food waste. The options presented in this section of the figure are the most preferable ways of dealing with food waste: the best outcome is reduction at the source (21). This hierarchy also views the redistribution of food to human mouths, or as animal feed to be prevention rather than waste because this food is kept within the food supply chain (i.e. fed to humans, or fed to animals which will, in turn, be fed to humans (21, 22). However, food donated directly for human consumption is preferable to donation of food to animal feed (21). As shown

in the figure, the next stages down the food waste hierarchy are all considered to be waste, as food prematurely exits the supply chain. Recycled, recovered and disposed product fall under the category of waste, however, are considered most to least favourable, respectively (21). Although this version of the hierarchy is relatively new, the priority of waste prevention, followed by recovery and lastly disposal was articulated in the European Community Strategy for Waste Management in 1989 (23). Several authors and organisations including Papagyropoulou et al. (24), and the Environmental Protection Agency in the US have designed food waste hierarchies with these principles in mind (25). However, the WRAP hierarchy has been presented in this thesis as it makes a distinction between prevention and waste, and because it prioritises different options for dealing with food waste.

2.3 Studies of food waste throughout the food supply chain, including the retail sector

2.3.1. Global estimates for food waste

Food waste is generated at each stage of the food supply chain, including: production, handling and storage, processing and packaging, distribution and retail (also referred to as distribution and market, or wholesale and retail) and finally, consumer food waste (i.e. households) (8). Edible food waste across the food supply chain has been calculated globally to be one-third of total food produced for human consumption, or about 1.3 billion tonnes per annum (1).

Research into food waste across the food supply chain is commonly quantified by extrapolation of data from food balance sheets to produce global food waste estimates (1, 8,26). In 2011, Gustavsson et al. from the Swedish Institute for Food and Biotechnology published a paper in conjunction with the Food and Agriculture Organisation (FAO) that aimed to assess global food losses across the entire food supply chain (1). FAO food

balance sheets for production and utilisation (2007), existing literature, and assumptions (i.e. estimating food waste in countries with no available data using data from similar countries) were used by the researchers to estimate edible portions of food losses and waste across the supply chain (1). Estimates were made for seven global regions (i.e. Europe, North America/ Oceania[1], Industrialised Asia, Sub-Saharan Africa, North Africa and West/Central Asia, South/Southeast Asia and Latin America) (1). It is important to note that the FAO only include Australia and New Zealand in their food balance sheet data for Oceania (8). Europe and North America/Oceania were estimated to be the largest contributors to edible food loss and waste per capita, with a total of 280-300kg/capita/year (1). Due to non-standard methods of data collection and bias from assumptions, estimates using food balance sheets should be interpreted with caution (1). However, for the purposes of making global and regional inferences this is the best available information, to date (1).

Measuring waste in weight (i.e. kilograms and tonnes) does not account for the water content and caloric value of food waste (8). In 2012, Kummu et al. quantified food loss across the food supply chain in units of kilocalories (kcal) using FAO food balance sheets from 2005-2007 (26). The authors concluded that North America and Oceania produced the largest food losses per capita at 1334 kcal/capita/day (26). In 2013, the World Resources Institute (WRI) conducted a similar analysis to Kummu et al. (8). This analysis resulted in a drop in the estimation of total global food waste from 33% estimated by Gustavsson et al. (1), to 24% of global food production (8). When broken down into kilocalories (kcal) wasted per capita per day, the World Resources Institute calculated food waste arising in North America/Oceania to be 1520 kcal/capita/day (8), similar to

[1] Oceania includes Australia and New Zealand. The FAO data combines North America and Oceania together. One cannot split the data apart (8).

the results obtained by Kummu et al. (26). This is unsurprising considering the data used and units of quantification (i.e. kcal) were the same in both studies. The World Resources Institute calculated food waste in Europe to be 748 kcal/capita/day, the second highest estimate for global food wastage (8). They also estimated that food waste produced at a distribution and retail level in developed countries equates to approximately 5% of total food waste along the food supply chain (8).

It was estimated that the greatest proportion (39%) of calories lost in Sub-Saharan Africa were generated during the production stage of the chain, whereas 61 % of the calories wasted in North America/ Oceania occurred during the consumption stage of the supply chain (8). Kummu et al. also identified that in low income countries the majority of food waste was concentrated towards the production end of the supply chain (26). Conversely, in middle/high income countries, such as New Zealand, over half of the waste occurred during the distribution, retail, and consumption stages of the supply chain (26). This emphasises the need to focus on food waste reduction in the latter stages of the food supply chain in developed nations. Both Kummu et al. and the World Resources Institute identified that North America/ Oceania (i.e. Australia and New Zealand) are estimated to be the largest global contributors to food waste per capita in comparison to the other regions included in this study, emphasising the need for further research waste reduction in these two regions (8, 26).

2.3.2 National estimates for food waste

National estimates have also been generated for food waste in some countries, such as for the United States (US) and Switzerland, and for geographical regions such the European Union (17, 27, 28). Although these studies do not provide detailed insights into food waste at specific stages of the food supply chain, they are useful for providing an

overview of the distribution of food waste across the supply chain and to estimate the amount of food waste produced annually in different regions (29).

Food waste across the food supply chain is commonly calculated in two different ways, the kilograms of food waste produced per capita per year, and the kilocalories wasted per capita per day. Hall et al. and Beretta et al. both quantified food waste across the food supply chain in terms of kilocalories lost when food was wasted (17, 30). In 2009, Hall et al. used mathematical modelling to investigate the difference in the amount of food produced and amount of food consumed for the US food supply, in order to deduce the energy lost due to food waste in the US (30). Hall et al. used national food balance sheets produced by the FAO. Food intake was extrapolated from the 1974 US National Health and Nutrition Examination Survey (NHANES) to predict current food consumption in the US and was adjusted for increased intake since data collection in 1974 (30). They found that, on average, 900 kcal/capita/day or 30 % of the US food supply was wasted in 1974, and 1400 kcal/capita/day or 40 % of the US food supply in 2003(30). It is interesting to note that the 2003 estimate derived by Hall et al. is similar to that of Kummu et al. and the World Resources Institute in terms of the amount of kcal/capita/day wasted in North America and Oceania (8, 26).

Beretta et al. focused on quantifying supply chain losses at a national level in Switzerland in their study published in 2012; food waste was also quantified as the percentage of kilocalories lost at each stage of the supply chain (17). The researchers collected data about waste and losses throughout the supply chain from datasets provided by industry, organisations, and federal institutes in Switzerland (17). This may have introduced bias from self-reported industry data and inconsistencies in the definition of food waste and quantification methods used by each group that provided data (17). Food waste in the

retail sector amounted to less than 5 % of calories that entered the retail stage of the food supply chain. In total, approximately 48% percent of calories, equating to 299kg/capita/year, were wasted in the Swiss food supply chain (17), which is very similar to the European estimates of food waste reported by Gustavsson et al. at 280-300 kg/capita/year (1).

In 2016, FUSIONS quantified regional level food waste in terms of kilograms of food wasted per capita per annum (28). FUSIONS aimed to collate estimates for food waste produced during 2012 across the food supply chain in Europe (28). Data were provided by each country using the best available estimates for food waste they had, and thus methods of quantification varied between different countries. However, data were screened by the research team, and only data that aligned with the FUSIONS definition and used acceptable quantification measures were included (28). This was the first study to collate comparable food waste data using standard definitions (i.e. animal feed and food donated to charities were not classified as food waste) (11). It was estimated that a total of 173kg/capita/year were wasted within the European Union in the year 2012 (28). A mean of 9.4 kg/capita/year was wasted at a retail level, with a range of 3.9 kg/capita/year to 29.8 kg/capita/year (28).

2.4 Studies quantifying food waste in the retail sector

As previously mentioned, waste in developed countries is concentrated at the latter end of the food supply chain (26). Consumer food waste has been well researched in the literature. However, little publicly available data exist at a retail level, one step back along the food supply chain (31). Although retail food waste is estimated to contribute to a smaller proportion (i.e. <10%) of total food waste, amounts are still substantial (8). Retailers form a link between consumers and producers and can increase awareness for

food waste reduction both up and down the food supply chain (32). Retailers can introduce policies targeted at food waste reduction within individual stores and across entire retail chains, which can have large impacts on food waste reduction in the sector (32).

Measuring retail food waste is an important step to understanding the scale of the issue and areas to target for waste reduction in the sector (7). Baseline data are necessary for monitoring the progress towards food waste reduction goals (7). In more recent years a few key studies have been undertaken in an attempt to generate baseline data for the sector (18, 21, 32-34). Various methods have been used to estimate the quantity of retail food waste produced in different countries, which can make it difficult to draw comparisons between studies. Many studies have analysed data from store databases, delivery records, and store sales data provided by retailers (18, 31-35). Some studies have also included onsite waste audits to measure the quantity of food waste (18, 32, 33), whilst others have conducted interviews with retail staff to obtain estimates for food waste (36, 37). Retailers are also beginning to publish their estimates for in-store food waste (38).

2.4.1 The Waste and Resources Action Programme

The Waste and Resources Action Programme (WRAP) is an organisation/charity in the UK that has contributed to the available literature on retail food waste (18). In 2005, WRAP established The Courtauld Commitment, a voluntary agreement within the UK grocery sector aimed at reducing waste, which retailers have followed since 2009 (39). WRAP works in partnership with retailers, brand owners, suppliers, and manufacturers towards achieving the targets set out in the agreement (39). In 2012, WRAP conducted research into the quantity of food waste produced across the grocery supply chain (i.e.

manufacturing, wholesale, and retail food waste) (21). Data were compiled from reported estimates for food waste for 2011 from retailers that were part of the Cortauld Commitment and then scaled up to a national level (21). Food waste that was diverted to animal feed was not included in these estimates, as waste diverted to animal feed was calculated for the entire supply chain as a whole, and not specifically for the retail sector (21). WRAP estimated that a total of 427,000 tonnes of food were wasted in the UK retail sector annually, with an additional 2117 tonnes of unsold food (and packaging) donated to food rescue charities (21). This estimate was not able to be separated into individual food categories (i.e. bakery, vegetables, dairy).

In 2016, WRAP released a report with more comprehensive quantitative data on food waste and surplus in the UK manufacturing and retail sectors (18). The study aimed to identify the potential for redistribution of edible food waste, known as food surplus (18). Data were presented separately for food waste and surplus in the manufacturing sector and for the retail sector, and thus, this literature review will focus on retail sector estimates. Both the standard definition for food waste and food waste quantification guidance manual (refer to Section 2.5) developed by FUSIONS were adhered to for this study (11, 22). The study presented updated estimates on the quantity of food waste in the UK grocery sector. Pre-existing data for 2014 were provided by the British Retail Consortium which represented 82.5% of the UK retail sector, and were then scaled by WRAP to represent 100% of the sector (40). Retail food waste alone was estimated to be 210,000 tonnes per annum (18).

In 2015, retail food surplus (i.e. food able to be redistributed) was quantified using a three component study design including: analysis of industry data; onsite audits; and interviews with key stakeholders to understand food surpluses arising in the UK retail supply chain

(18). Data from three major retail bodies was analysed in the study and WRAP carried out seven site-based audits and interviews. A range of store formats were sampled including: three large format stores; one regional distribution centre; and three convenience stores. Interviews with retail staff were held to gain an understanding of policies and decisions governing food redistribution. Data obtained from all three components were used to generate estimates for total retail food waste and surplus for 2015 (18).

WRAP reported that approximately 240,000 tonnes of food waste and food surplus combined is generated at a retail level in the UK each year, representing 0.7% of food sold annually and 2% of total food waste in the UK (18). This estimate includes both the figure for food waste calculated using pre-existing data (i.e. 210,000 tonnes) and a new figure for food surplus (i.e. food directed to animal feed and donated for human consumption) (18). Approximately 27,000 tonnes of food were redistributed to animal feed and 5,000 tonnes to humans (18). Although data were separated out by food category (i.e. bakery, fruit, and vegetables) for the manufacturing sector, this level of detail was not available for the retail sector. The 2014/15 estimate for food waste and surplus of 240,000 tonnes generated by WRAP (18) is substantially less than the 2011 estimate of 427,000 tonnes of food waste and 2,177 tonnes of donated food (21). It is possible that the increased awareness for food waste and prevalence of waste reduction initiatives in the retail sector may have contributed to a reduction in retail food waste over the 3-4 year period. Differences in data sources for the quantities of food waste and surplus may also explain the difference in the estimates.

2.4.2 Quantities of food waste reported by retailers

Many retailers have systems in-store that collect accurate data on food waste (38).

Making this data available to the public may increase accountability for retailers to responsibly handle their food waste. With the drive for transparency in the reporting of food waste data (41) the Tesco supermarket chain in the UK and Europe have made their data publicly available (38). Food waste is measured at all Tesco depots and stores, and calculated over the period of each financial year in accordance with the Food Loss and Waste Accounting and Reporting Standard (see Section 2.5) (41). Tesco use the FUSIONS definition of food waste, which includes the edible and inedible parts of food, and excludes donated food and food directed to animal feed (11). However, they also report food surplus which includes all food waste, animal feed, and donated food (38). Total food waste and surplus amounted to 71,178 tonnes in UK stores (38). Over the financial year spanning 2016 and 2017 the food categories that contributed the most to overall food waste (excluding donated food) in the UK were produce (35%), chilled product (26%), meat, agriculture, and local product (9%), and bakery (8%) (38). Tesco stores are also located in the Republic of Ireland and that data is published separately. In the year 2016-17, total food waste and surplus amounted to 6,521 tonnes (42). The top four food categories (excluding donated food) included produce at 29%, chilled product at 23%, bakery at 22%, and meat, agriculture, and local product at 12% (42). Tesco also have stores in Central Europe. In 2016-17 total food waste and surplus amounted to 60,918 tonnes (43). The top four food waste categories (excluding donated food) consisted of produce (39%), bakery (25%), ready to eat foods (9%), and dairy (8%) (43). Tesco have pledged that no food safe for human consumption will go to waste by the end of 2017/18 (44).

Every two years since 2012 the Food Waste Reduction Alliance has collected food waste data from manufacturers, retailers, wholesalers, and restaurants in the US in the form of a survey (45). The survey includes questions on the topics of food donations, food reused

or recycled and food sent to landfill as well as perceived barriers to further diversion and donation (45). A total of 24 retail bodies and wholesalers representing over 10,700 stores (covering 35.3% of retailers and wholesalers in the US) were surveyed and results are presented for the two sectors combined (45). The Food Loss and Waste Accounting and Reporting Standard (see Section 2.5) was considered when generating estimates for the quantities of food waste produced (41). In 2016, it was found that 54.3% of total food waste was recycled or diverted, 18.1% was donated, and 27.6% was destined for landfill (45). The most common diversion streams were animal feed (24% of diverted waste) and composting (24% of diverted waste) (45). In 2012, the most dominant barrier to further diversion was concerns for liability (45). The 2014 report found insufficient refrigeration, storage space, and transportation to be important barriers (46), and in 2016 transportation was the most significant barrier (45). Although self-reported food waste quantities and lack of third party validation of data may have introduced bias, both Tesco and the Food Waste Reduction Alliance followed guidance from the Food Loss and Waste Accounting and Reporting Standard (see Section 2.5) (41).

2.4.3 Interviews with retail staff to quantify food waste

Some studies have also attempted to quantify the amounts of food waste produced at a retail level through interviews with key retail staff members (36, 37). In 2008-09, Mena et al. conducted a series of 43 semi-structured interviews with retailers and suppliers in both Spain and the UK recruited through convenience sampling (i.e. selecting a sample based on ease of accessibility) (36). Data obtained during the interviews was used to estimate the quantity and destination of wasted food for a variety of product categories (36). Over 7% of bread, oils, sandwiches, yoghurt, beef and bagged salad were estimated by retail staff to be wasted, with 3-7% of fresh fruit, vegetables, fish, poultry and margarines estimated to be wasted (36). The most common food waste destinations included

charities, secondary markets (i.e. discount stores), biogas, and landfill (36). In the UK raw meat, fish and poultry cannot be discarded in landfill, therefore rendering, incineration, composting or biogas production are common destinations for protein (36).

Stenmarck et al. attempted to quantify food waste in Nordic countries by reviewing existing estimates in the literature (37). However, estimates for retail food waste quantities in Finland were ascertained from information provided in six interviews with retailers (37). The authors commented that this data was difficult to obtain due to the commercial sensitivity of it (37). In Finland, all food waste is weighed and recorded by retailers and used to improve processes in-store. Although retailers were not willing to share exact data, a number of interviewees expressed approximate percentages for food waste in-store (37). An average of 1-2% of total food sold was estimated to be wasted. Stenmarck et al. used this value to estimate food waste for the retail sector in Finland, which amounted to 65,000-75,000 tonnes per annum (37). Although estimates from interviews are not as precise as direct measurement of food waste, they can be the most appropriate method when access to sites or to information is difficult.

2.4.4 Case studies to quantify retail food waste

The aforementioned studies and reports obtained their data from industry datasets, onsite waste audits, and interviews. Another approach to collecting data on retail food waste is to conduct a case study to monitor one store's waste over time (31, 35). This data is likely to be less representative of a country or region's retail food waste. However, it may provide more robust data at a store level (29). The two case studies discussed in this literature review used store records to obtain data. Stores scan or manually enter information on wasted food into an in-store database (31, 35).

In 2012, Cicatiello et al. recruited one supermarket in Italy as a case study to measure quantities of donated food (31). As this study focused solely on quantities of food donated, it only encompassed the edible food waste that was safe for human consumption, which is not in line with the FUSIONS definition (11). Each day, retailers scanned and entered details of all donated food products into a database which was made available to the research team (31). It was found that over the period of the year 2012, 23.5 tonnes of edible food were donated to the food recovery organisation used by the case study supermarket, with bread contributing to 70% of the total weight of donated food (31). Cicatiello et al. concluded that retail food waste in Italy was significant, although it was a small proportion of total food waste (31). The authors suggest this smaller contribution to total food waste may explain the lack of food waste literature focusing specifically on retail food waste (31). However, with an estimated 4.4 million tonnes of food (i.e. 5% of total food waste) being wasted in the European Union retail sector annually, reduction is still essential (47).

Other case study approaches to quantifying retail food waste have been undertaken, including the study of one Swedish supermarket conducted by Brancoli et al. between 2014-2015 (35). This study measured both avoidable and unavoidable products together with the assumption that all food was edible prior to being wasted (35). All food that was not sold in the supermarket was scanned into a database using the barcode on the food package, and if the item did not have a barcode this was manually entered into the database (35). The data collated in the database were used to calculate the quantity of retail food waste in the store. It was found that the supermarket produced 22.5 tonnes of food waste over the study period (35). The quantity of waste observed by Brancoli et al. was similar to the quantity of food donated by the Italian supermarket studied by Cicatiello et al (31). However, Brancoli et al. account for all food waste and Cicatiello et

al. only account for donated food (31). Bread was wasted in large quantities (i.e. 30% of total weight of waste) and had the largest environmental footprint and cost of all food categories measured. It was emphasised that bread should be a key target for waste reduction (35).

2.4.5 Quantification of specific food categories

Some studies have quantified specific food categories at a retail level (32-34). Studies that focus on specific products often use datasets provided by stores or suppliers that cover a time period of one or two years (32-34). Some researchers will audit a small subsample of stores in order to assess the accuracy of reported data (32, 33). An example of such an approach is the study by Eriksson, who quantified retail food waste in Sweden by analysing food waste datasets provided by retailers, and by recruiting a convenience sample of six supermarkets in Uppsala for onsite food waste audits (32). Quantities of fruit and vegetable, dairy, cheese, meat and deli waste were recorded over a one year period from 2010-2011. Food that was to be discarded was recorded by retail staff in each store, a procedure that was part of the store's systems (32). Food products with barcodes were scanned into the store's database, and manual recording was done by a manager for fruit and vegetables. Fresh fruit and vegetables made up 83% of the waste recorded over the five food departments (32). Throughout the period of the study 3% of fresh fruit and vegetables were rejected on arrival, whereas in-store waste was approximately 1.3% for fresh fruit and vegetables. The researchers established that 4.3 % of fresh fruit and vegetables delivered to Swedish retail stores were wasted (32).

A similar study design was employed by Lebersorger and Schneider to investigate the quantity of fruit and vegetables, dairy, and bread and pastry waste at a retail level in Austria (33). The purpose of this quantification process was to provide baseline data to

identify and target specific areas for food waste prevention, and as a means of monitoring future interventions. Data were collected from 612 retailers in Austria over a one-year study period from 2011-2012 (33). The primary source of data was self-recorded food waste from databases of the retailers involved. However, onsite audits (referred to as 'sorting analysis' in the study) were carried out in six retail outlets, with each store being audited on two days in April 2013 (33). Of the total audited waste, 68% was attributable to fruit and vegetables, 6% to dairy, and 7% to bread and pastry (33). Other food categories were also audited (i.e. beverages, meat, pre-prepared foods, and confectionery) which amounted to 19% of total waste recorded (33). Results for store-reported data were presented in terms of mass and monetary loss in comparison to total sales for the categories of fruit and vegetables, bread and pastry, and dairy (33). In total 2.8% of the mass of these product categories was wasted, equating to the 2.6% of the monetary value of the total sale of these product categories (33). It was also estimated that 53% of the total monetary value of food products wasted across the three food categories were fruit and vegetables (33). The authors reported that of all fruit and vegetables measured in the Austrian retail sector, 4.2% of product delivered for sale was wasted, similar to the 4.3% estimated for the Swedish retail sector by Eriksson (32).

Buzby et al. quantified retail 'shrink' and food loss in US supermarkets. Shrink (also known as shrinkage) can be referred to as food that is delivered to the supermarket that is not sold (34). The research team analysed supplier-shipment data and sales data to estimate food loss in 2005 and 2006 for 600 stores across the US (34). In 2013, the data was updated. Data were collated for 2900 stores across the US from 2011 and 2012, a much larger sample than in the previous study (34). In the 2013 study, stores were recruited via convenience sampling, therefore the results of the study are not nationally representative. Three major food categories were investigated including fruit, vegetables,

and the category of ‘meat, fish, poultry, and seafood’ (34). The amount of fruit shrink increased slightly from 11.4 % in 2005-06 to 12.6% of fruit in 2011-12 (34). In terms of vegetable shrink, the percentage of delivered vegetables lost also increased from 9.7% to 11.6%, and the amount of meat, fish, poultry, and seafood loss increased substantially from 4.5% to 12.7%, respectively (34). The authors suggested that one plausible reason for the increase in food loss was that the range and quantity of fresh products that supermarkets stock had increased (34). It was also hypothesised that retailers may have improved the reporting of food loss quantities, thus the 2005-06 estimates may have underestimated food loss (34). In both studies the percentage of wasted fruit and vegetables delivered to stores for sale was greater than that presented by Eriksson in Sweden, and Lebersorger and Schneider in Austria (32, 33).

A variety of study designs and waste quantification methods have been implemented in the literature reviewed. A standardised protocol for quantifying retail food waste, including data collected by industry, would provide more accurate and generalisable estimates.

2.5 Standard protocol for quantifying food waste

In 2010, the European Commission identified a need for coherent and consistent food waste quantification within the European Union, as understanding of existing levels of food waste were poor. The Food Loss and Waste Accounting and Reporting Standard, published in 2016, was developed by world leaders in waste reduction, including the World Resources Institute (WRI), the Waste and Resources Action Programme (WRAP), European Union Fusions (FUSIONS), and the United Nations Environment Programme (UNEP) (41). This global standard provides organisations and researchers with guidelines for conducting food waste quantification across the supply chain, with the aim of

collating comparable data. The document provides a template for defining the scope of a quantification study including: the timeframe food waste will be measured over; the material types that will be measured; the destinations that food waste is directed to; and the boundary of the study (i.e. the food categories to be measured, life cycle stage, geographical area and organisations involved) (41). The Food Loss and Waste Accounting and Reporting Standard also provides guidance on choosing the quantification method. The report states that the most accurate measure for assessing food waste is by direct weighing in the form of an audit (41). However, gaining access to physically measure food waste is not always possible.

FUSIONS have also produced the Food Waste Quantification Manual to Monitor Food Waste Amounts and Progression (22). This manual was developed specifically for food waste assessment within the European Union (EU). Recommendations in the FUSIONS document reinforce those made in the Food Loss and Waste Accounting and Reporting Standard. However, unlike the Standard, the FUSIONS manual provides recommendations for quantifying food waste specific to each stage of the food supply chain (41).

Together, these two documents provide assistance for developing the overall food waste quantification process (22, 41). More specific guidance for undertaking a waste audit was produced by the United States Environmental Protection Agency's Sustainable Materials Management in their manual 'A Guide to Conducting and Analysing a Food Waste Assessment' (25). The manual includes step-by-step guidelines for conducting an onsite audit, as well as recommendations on how to organise the sorting area; how to conduct the sorting process; and provides data collection templates (25).

2.6 Qualitative methods used to assess retail food waste

In addition to collecting quantitative data on food waste, qualitative research can also be useful to gain knowledge of the perspectives of retail staff on food waste in-store and the environment in which food waste is generated (48). Insights provided by retail staff are crucial in developing effective waste reduction initiative, as it is the staff who carry out waste management procedures at a retail level. Such findings can help to inform the most effective ways to implement change. However, qualitative studies in a retail food waste context are limited.

Gruber et al. conducted a series of 32 semi-structured interviews with retail store managers in their study published in 2016 (48). While the study location was not disclosed, all participants interviewed were recruited from the same country. Interviews lasted for 100 minutes in duration and comprised a series of questions that aimed to understand the respondents' position and behaviour concerning food waste (48). The research team followed a protocol outlined by Hsieh and Shannon for thematic analysis (49). The most dominant theme across the data set was the store manager's personal views on food waste (48). The overarching theme of the 'human morality' of food waste, and the constraint that store managers experienced were identified as contributing factors to an increased sense of moral burden (48). Potential solutions and recommendations for change were discussed including public policy initiatives to reduce constraints experienced by store managers and proposals for more flexibility for managers to act to reduce food waste within their store (48).

Filimonau and Gherbin conducted research into managerial attitudes towards food waste mitigation at a retail level in the UK in 2016 (50). A series of 12 in-depth semi-structured interviews with retail managers were undertaken with the aim of uncovering attitudes

held by key retail staff (50). Interviewers asked questions relating to three broad categories: managers' knowledge on the magnitude of food waste in the UK retail sector; approaches to retail food waste management; and the role of key stakeholders and corporate policy in the mitigation of food waste (50). Thematic analysis was used to analyse the interview responses by coding data into dominant themes (50). The majority of managers did not believe that food waste was a major issue at a retail level, even though corporate policy reflected food waste reduction as a priority (50). In terms of waste mitigation practices, food recycling and food donation were the most dominant subthemes across the dataset (50). Another dominant theme mentioned throughout the course of the interviews was the barriers to food waste reduction, including consumer awareness and purchasing behaviour; corporate policies; suppliers; employees; and supermarket size (50). It was identified during interviews that managers believed larger outlets were more likely to have larger quantities of food waste (50).

In 2014, Hocke published a thesis on the potential for retail food waste reduction in Dutch supermarkets (51). This qualitative study aimed to identify the leverage points for retail food waste reduction, the drivers (i.e. motivators) and obstacles (i.e. barriers) to retail food waste reduction, and to provide policy recommendations to overcome the obstacles and re-inforce the identified drivers (51). The study used an inductive (data-led) grounded theory approach, as there was little existing theoretical knowledge in the area, thus a theoretical approach was not appropriate. A series of five semi-structured interviews were carried out over the course of the study (51). The importance of the obstacles and drivers identified in the interview were quantified in terms of frequency of articulation by participants (51). Twelve key variables were identified to food waste reduction. Profitability was the most frequently mentioned obstacle and driver at a retail level. Lack of profitability was perceived as an obstacle to reducing food waste, including

logistical costs and lack of profitability associated with food donation (51). Increased profitability was also identified as a driver for reducing food waste, as both disposal costs and loss of profit from unsold product would be reduced if less food was wasted (51).

Due to the dearth of qualitative literature focusing on retail food waste, it is useful to look at qualitative research in the household sector. In 2011, a study by Graham-Rowe et al was conducted to identify the motivators and barriers to minimising household food waste in the UK (52). This study interviewed 15 individuals from 13 households throughout the UK. Semi-structured interviews focused on the general topic of thoughts and feelings associated with food waste behaviours (52). Thematic analysis was used to analyse the results of the interviews, and data were coded into motivators and barriers associated with reducing food waste (52). Waste concerns and doing the 'right' thing were considered as motivators identified by participants for reducing food waste (52). Four barriers were identified to food waste minimisation including: being a 'good' provider; minimising inconvenience; lack of priority; and exemption from responsibility (52).

Several qualitative studies have also attempted to identify the causes of retail and wholesale food waste through interviews with key stakeholders. Stenmarck et al. investigated retail and wholesale food waste in Nordic countries (as referred to in Section 2.4.3) and found that store quality requirements and expectations of customers were significant contributors to food waste (37). Systems for forecasting and ordering were also identified as key contributors to the quantity of food waste produced, while predicting customers shopping habits was perceived to be difficult. The storage and handling of food, and also the issues related to date labelling were mentioned as causes for food waste (37).

Another study conducted by Mena et al. interviewed 43 retailers, wholesalers, and manufacturers across Spain and the UK (36). Causal maps were constructed in an attempt to understand the root causes of retail food waste (36). Three overarching themes were identified as causes for retail food waste including: mega-trends in the market (i.e. increased demand for preservative-free product); natural constraints (i.e. shelf-life, weather fluctuations); and management root causes (i.e. waste management procedures) (36).

2.7 Food waste literature in New Zealand

There are few studies that have measured food waste in New Zealand (10, 53), and no studies on retail food waste. The following section provides a brief overview of the available literature quantifying food waste in New Zealand across the food supply chain.

Food waste in New Zealand has been quantified at a household level. However, other areas throughout the supply chain have received little attention. The Waste Management Institute of New Zealand (WasteMINZ) commissioned research to measure the quantity of waste produced in domestic households throughout the country (10). WasteMINZ modelled their methodology on methods developed by WRAP using a range of urban and rural households, deciles, and kerbside collection system (i.e. bags or wheelie bins). Waste was collected from 1402 households and each household's waste was sorted by hand into food categories (10). The waste for each category was then weighed and recorded and classified as avoidable, potentially avoidable or not avoidable (10). WasteMINZ reported that 229,022 tonnes of food waste are included in kerbside refuse collection in New Zealand households per annum (10). Of this, 54 % was estimated to be avoidable, 12% potentially avoidable, and 35% non-avoidable (10).

Reynolds et al. undertook a study that aimed to estimate the tonnes, value, calories, and resources wasted as a result of food waste in New Zealand in 2011 (54). Estimates for tonnage were generated using input-output tables from the Ministry for the Environment's data on monthly landfill waste-levies (54). Estimates were inferred through calculations and no physical measurement of waste was undertaken. From these estimates, Reynolds et al. assumed that food waste made up 17 % of total waste in New Zealand, amounting to NZD 568 million (54).

A mixed methods study conducted by Ross in 2014 focussed on the quantity and reasons of food waste in airline food service (53). Onsite audits in two airline kitchens were conducted to quantify food waste in this sector. Both observations and thematic analysis of semi-structured interviews with 19 staff members were carried out to identify the key drivers of food waste in the sector (53). It was estimated that 57.3 % of total airline waste was food product. Of the food waste, 40.3% were vegetables, followed by 11.9% meat and fish (53). Thematic analysis was used to code qualitative data into themes. The three most significant themes identified as contributing to waste generation in interviews were: menu development and forecasting; staff attitudes; and staff behaviours (53). The methodological approach to assessing food waste used in this study was useful in providing both quantitative data on airline food waste, and qualitative data to inform future waste reduction initiatives.

A few other studies have been conducted at a few hot spots along the food supply chain. These studies tend to be qualitative, and particularly focussed on the area of food waste in food service in hospitals (55), and residential halls (56, 57). Other qualitative studies including Niimi (58), Parr (59), and Stoddart (60) have investigated household food waste in a New Zealand context.

Although research has been conducted in a New Zealand context in relation to food waste, both quantitative and qualitative data is limited. The research into household food waste commissioned by WasteMINZ is the most robust data in terms of generating national estimates for the quantities of food produced in New Zealand. This lack of baseline data shows a need for further food waste quantification exercises in other sectors in New Zealand.

2.8 Retail food waste in New Zealand

There appears to be no publicly available data quantifying retail food waste in New Zealand. However, the two major retail bodies in New Zealand, Countdown and Foodstuffs, have begun to take action to reduce food waste produced in the retail sector. Countdown has announced targets (i.e. action towards zero waste to landfill by 2020) (61), and launched initiatives (i.e. The Odd Bunch misshapen fruit and vegetable campaign) in attempt to reduce their food waste (62). Countdown supports food rescue charities nationwide by donating fresh and packaged foods that they are no longer able to sell. Countdown has also announced that 100% of their stores participate in food donation (61). In 2017, an estimated NZD 5.8 million of food was donated to charities and farmers in New Zealand (61). Foodstuffs, have also publicised their commitment to food waste reduction. Foodstuffs launched a national waste minimisation programme in 2012 designed to minimise landfill waste (63). Of stores eligible to take part in the programme, 90% have joined (64). In the 12 months leading up to November 2016, 900 tonnes of food waste were diverted away from landfill in stores participating in the programme (64). Foodstuffs is also actively involved in food donation, including fresh food donation. In the same 12-month timeframe stated above, 2.4 million meal equivalents were donated to food rescue partners (64).

2.9 Conclusion

After reviewing the literature, although the proportion of food wasted in the retail sector is estimated to be relatively low (i.e. 5% of total food waste) in comparison to other areas, the quantity and cost are significant (31). Reports using global data emphasise that economically developed regions (i.e. North-America and Oceania) are the largest contributors to food waste per capita, and that waste in these regions is concentrated towards the distribution, retail, and consumption end of the food supply chain (8, 26). Global estimates for food waste are approximations commonly derived from food balance sheets, as well as economic, industry, and survey data. As the focus for food waste quantification becomes narrower, for example focussing on one stage of the food supply chain, the method of quantification can be more precise. This includes onsite waste audits and interviews, rather than the extrapolation of data from large datasets (29).

Internationally, few studies have attempted to quantify retail food waste, and methods used to measure waste vary within the literature reviewed. Furthermore, quantitative research for retail food waste include very few onsite measurements of retail food waste, with the largest number of audits being seven stores or retail outlets (18). Many studies rely on industry estimates for their main source of data that may not use standardised methods of quantification (8). Standard protocol for food waste quantification have been developed in order to allow for the collection of more comparable quantitative data for food waste (22, 41). The Food Loss and Waste Accounting and Reporting Standard recommend that onsite food waste audits, although resource intensive, provide the most robust quantitative data for food waste (41).

In addition to measuring the amount and type of food wasted, it is important to understand the underlying reasons for food waste. Qualitative literature for retail food

waste appears to be limited. However, studies in this area typically carry out semi-structured interviews with retail staff to gain insights into behaviours, attitudes and intentions (48, 50), as well as key motivators and barriers to reducing food waste (51). Thematic analysis appears to be an appropriate technique used to analyse qualitative data from interviews with key retail staff in order to uncover the most dominant themes mentioned throughout the dataset (48, 50).

There is a clear gap in the literature in relation to both quantitative and qualitative data for retail food waste in New Zealand. With both major retail bodies in New Zealand committed to food waste reduction in their stores, it is timely to generate baseline data for the sector for retailers to measure the effectiveness of the future waste reduction initiatives against. It is also useful to understand the motivators and barriers to food waste reduction at a retail level. This research will provide qualitative insights and quantitative estimates for food waste within the retail sector in New Zealand, and will contribute to developing a better picture of the quantity of food wasted in New Zealand.

3 Methods

This research was a mixed methods, observational study to assess retail food waste in New Zealand conducted in supermarkets from both major retail bodies (Countdown and Foodstuffs). The study had the following aims:

1. To estimate the quantity of food waste produced in the New Zealand retail sector.
2. To understand motivators and barriers to food waste reduction in the New Zealand retail sector.
3. To draw comparisons to data on food waste collected by New Zealand retailers.

The study consisted of three parts: onsite food waste audits undertaken in stores; interviews with key retail staff in stores; and obtaining existing data from retailers. In each participating store, food waste was measured over a 24-hour period and one store representative was interviewed. Onsite food waste audits and interviews with key retail staff occurred from June to August 2017. Food waste data collected by the retailers in 2016 and 2017 were provided by both retail bodies. Ethical approval for this study was obtained from the University of Otago Human Ethics Committee (reference no. D17/137), see Appendix 1.

The rationale for the study methods is presented in Section 3.1. The recruitment process by which retail bodies and individual stores were contacted, and their participation obtained, is explained in Section 3.2. Each subsequent section of this chapter will present the process undertaken for onsite food waste audits, interviews with key retail staff, and use of existing data provided by retailers separately. The methodological development for each of the study components is explained in Section 3.3. The data collection process is detailed in Section 3.4, followed by the data entry and cleaning process in Section 3.5. Lastly, the data analysis process for each part of the study is described in Section 3.6.

3.1 Rationale

The general study design followed a three-component methodology used by the Waste and Resources Action Programme (WRAP) in the United Kingdom (18), developed using the FUSIONS quantification manual guidelines (22). WRAP's three component model consists of: onsite food waste audits; interviews with key retail stakeholders; and analysis of existing food waste data (18). This three-component model was chosen in order to collect quantitative data for retail food waste (i.e. onsite audits), to gather qualitative data to inform future waste reduction interventions (i.e. interviews), and to account for variation in food waste quantities over time (i.e. existing data). Adoption of this three component model would allow for comparisons with international data.

3.2 Recruitment

3.2.1 Recruitment of retail bodies

As the publication of food waste data is of a sensitive nature to retailers, obtaining agreement from the two major retail bodies in New Zealand was a crucial component of this project. Considerable time was spent building relationships with Countdown and Foodstuffs to gain their participation in the study. Telephone and Skype meetings took place between the research team and nominated representatives from each retail body to establish a scope for the study that would satisfy the requirements of all parties involved. Face-to-face meetings also took place, where the retail representatives assisted with the methodology of the study. From initial contact in November 2016, confirmation from both participating parties occurred in April 2017.

3.2.2 Sample size selection

Typically, international retail food waste quantification studies have carried out onsite food waste audits in fewer than 10 individual stores, as small sample sizes are typical for research this sector (18, 32, 33). Most studies used onsite food waste audits to supplement

the analysis of existing retail food waste data. However, as this was the first study to measure retail food waste in New Zealand, and there was no publicly available data for the sector, the research team felt a larger sample size would be useful. A sample of 16 stores was agreed by the research team and the retail bodies as an achievable number of stores to audit within the 3-month window available for data collection (i.e. June to August 2017).

3.2.3 Recruitment of stores

A convenience sample of 16 supermarkets in New Zealand was recruited to take part in the study. Nominated representatives from each retail body were asked to select eight stores to participate in the study, and of those eight stores, two were from Auckland, Wellington, Christchurch and Dunedin. Both retail bodies have in-house waste minimisation programmes that run in conjunction with their waste contractors, and thus were asked to recruit a selection of medium-sized stores, both on and off their respective programmes. Foodstuffs has two brands of stores (PAK'n'SAVE and New World), therefore stores were selected from each brand. Nominated retail representatives were also asked to provide existing data on food waste pertaining to their respective retail chain.

Information sheets (Appendix 2) and consent forms (Appendix 3) were sent to each participating store before the data collection period commenced. Information was provided for both onsite food waste audits and semi-structured interviews, and the option to participate or decline each part was presented separately. All consent forms were signed and returned before each audit or interview took place in-store. All stores agreed to participate in both parts of the study.

A confidentiality agreement was also drawn up by legal advisers at the University of Otago in order to ensure that all store identification information was kept anonymous.

Due to information contained in the agreement, the confidentiality agreement cannot be attached as an appendix in this thesis. Ensuring the confidentiality of participating stores was one mechanism of addressing commercial sensitivity. This confidentiality agreement was signed by a University of Otago representative and a nominated representative from each retail body.

3.2.4 Recruitment of volunteers

Ten volunteers were recruited to assist the candidate with onsite food waste audits. Volunteers were recruited by emails sent to city councils in Auckland, Wellington, Christchurch, and Dunedin, and at the Dunedin campus of the University of Otago. All volunteers involved in the study were asked to sign a Confidentiality Undertaking to ensure that any commercially sensitive information remained private. The agreement cannot be attached as an appendix in this thesis due to confidentiality reasons.

3.3 Methodological development

This section explains the methodological development of the onsite food waste audits (3.3.1), interviews with key retail staff (3.3.2), and use of existing retail food waste data (3.3.3).

3.3.1 Onsite food waste audits

Site visits

In order to accurately develop food waste audit methods, site visits were conducted in four supermarkets from Wellington and Dunedin in April and May 2017. These visits consisted of back-of-store tours to observe how waste was collected, stored, and dispatched. The observed stores typically divided their waste into all, or some, of these five destinations: food donation, animal feed, compost, protein reprocessing[2], and landfill. Three of these destinations are listed in the Food Loss and Waste Accounting and

[2] The recycling of animal by-product (i.e. bone, fat, and meat scraps) fit for, but not intended for human consumption, into valuable commodities (i.e. fertiliser, pet feed) (14).

Reporting Standard (41). Food donation and protein reprocessing are not included in this standard protocol, but were measured in the present study as they are major waste and diversion destinations for food at a retail level in New Zealand.

The Food Loss and Waste Accounting and Reporting Standard provides a template to define the scope of a food waste quantification exercise (41). The scope for the present study is adapted from this template (Figure 3.1).

Scope for retail food waste audits

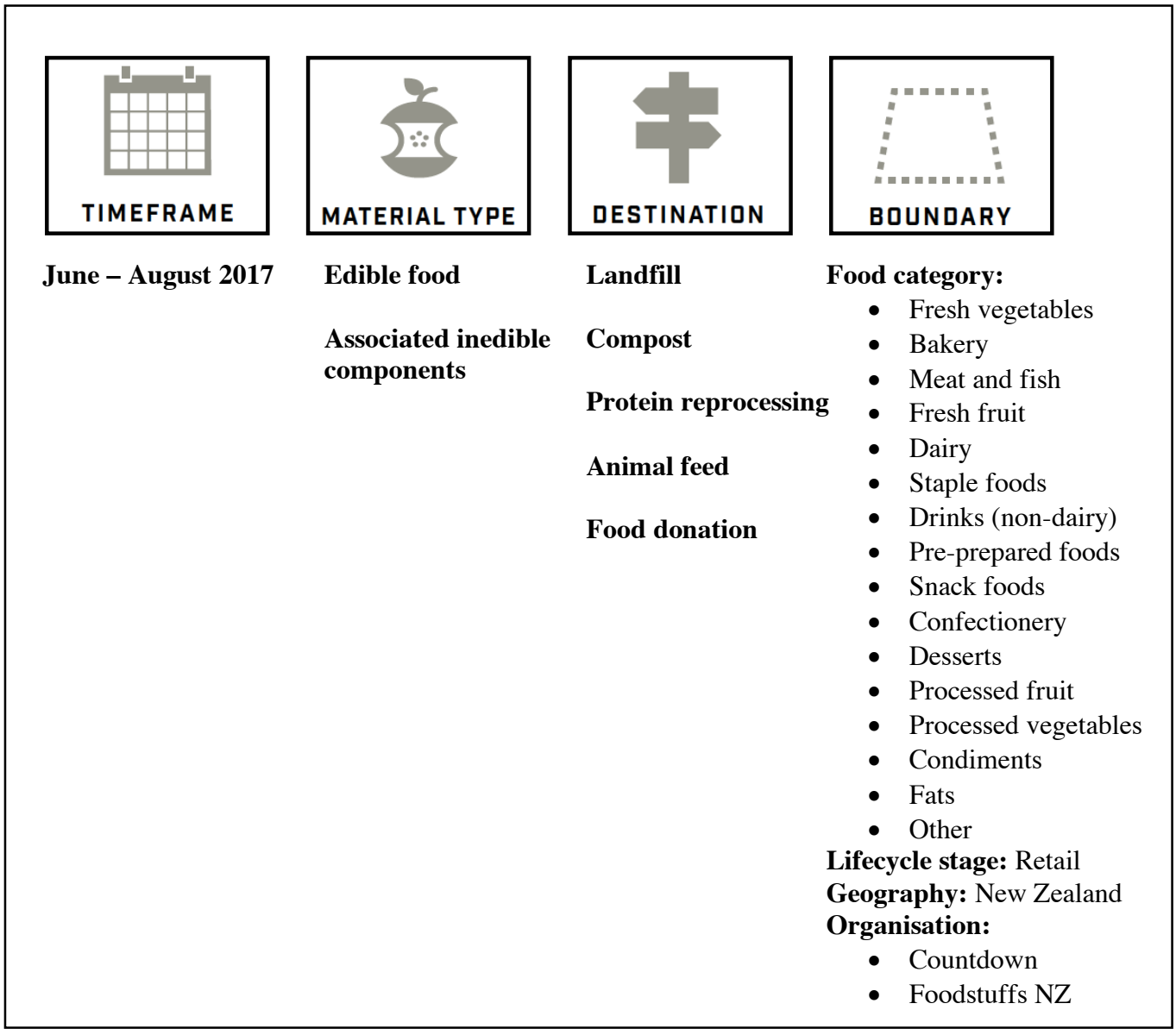


Figure 3.1 Scope of the present study using Food Loss and Waste Accounting and Reporting Standard template

Timeframe

It is recommended in the Food Loss and Waste Accounting and Reporting Standard that food waste data be recorded over a 12-month period to account for variation between seasons and within the year (41). However, there is no guidance provided on how frequently food waste data should be collected during this period (i.e. daily, monthly, quarterly etc.). This study collected data within a three-month timeframe to provide a 'first look' into retail food waste in New Zealand. Existing food waste data collected over the previous 10-12 months was requested from retailers. A question ascertaining if the quantity of food waste collected over the 24-hour period was typical, was included in the staff interview.

Material type

The FUSIONS definition for food waste used throughout this thesis includes both edible and associated inedible parts of food[3] (11). Therefore, edible and inedible components of food were weighed (i.e. an apple is weighed as a whole (core and flesh) as the purpose was to sell the apple as a whole) (18).

Destination

In each store, retail food waste is organised by destination (refer to Figure 3.1). It is important to note that FUSIONS excludes the destinations of animal feed and food donation from 'food waste', as food directed to those avenues is considered to remain within the food supply chain and is directly or indirectly used to feed humans (11). The research team still wished to collect data on these two destinations to understand the full extent of food that is not used for its original purpose (i.e. to be sold or utilised at a retail level). Therefore, the destinations: landfill, compost, and protein reprocessing are considered as 'retail food waste' (refer to definitions pg. 7), and the categories of food

[3] Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (11).

donation and animal feed are considered as 'retail food diversion'(refer to definitions pg. 7). For the purpose of this study dairy reprocessing and chicken fat reprocessing were excluded, as the timeframe for collection of these products typically exceeded 24-hours.

Boundary

The boundary includes food categories, life cycle stage, geography and organisation.

Food category

When dividing food into categories, the Waste Management Institute of New Zealand's (WasteMINZ) National Food Waste Prevention Project categories were adhered to as closely as possible in order to generate comparable estimates between the retail sector and household food waste sector in New Zealand (10). The candidate removed the category of homemade foods and added the category of snack foods in order to adapt the categories for use in a retail setting. Waste was divided and weighed for 16 different categories (refer to Figure 3.1). Following this, each category was then broken down by specific food type (e.g. carrots, bread, cottage cheese) and the WasteMINZ product categories were used when appropriate (Appendix 4) (10).

Lifecycle stage

The lifecycle stage was the retail sector. Although the FUSIONS food waste quantification manual requires measurement in the retail sector to occur from the arrival of food at the retailer's distribution centre until purchase by the consumer (22), this was beyond the scope of this study due to time and budget constraints. Therefore, food waste was measured from arrival at the retail outlet, through to purchase by the consumer.

Geography

Four locations across New Zealand were selected including Auckland, Wellington, Christchurch and Dunedin, and chosen as they are the two largest cities in the North Island and South Island, respectively (65).

Organisation

As referred to earlier in this Chapter, grocery retail in New Zealand is dominated by two overarching retail bodies, Countdown and FoodStuffs NZ, who are responsible for the three major supermarket brands of Countdown, PAK'n'SAVE and New World. In total, there are 377 supermarkets under the three brands, which represent 85% of supermarkets in New Zealand (66, 67). Brands with fewer stores (i.e. Fresh Choice, Super Value), convenience stores (i.e. Four Square), and boutique retailers (i.e. Nosh, Moore Wilsons) were excluded from the study.

Method of Food Waste Quantification

The principles outlined in the Food Loss and Waste Accounting and Reporting Standard (41), and the FUSIONS Food Waste Quantification Manual (22) were adhered to when choosing the quantification method used in the present study. Direct weighing was chosen as the primary method of quantification in this study as it is considered to be the most precise measure of food waste quantification (41). In some instances (i.e. for <15% of destinations), direct weighing was not possible due to access or safety issues. If direct weights for landfill food waste were not obtained, some stores provided data for wasted food products that had been scanned or entered into the supermarket's waste database (referred to as 'dumps') for a 24-hour period. For some waste destinations (i.e. animal feed), volume was used to obtain the weight of the waste when bins were too deep to retrieve and measure food. Assessing volume involved generating estimates from the physical space occupied by the waste, and using this to estimate the weight. A portion of the waste was transferred into a smaller container and weighed, then was multiplied by the number of smaller containers held within the capacity of the larger bin. When items were packaged, the net weight displayed on the packet was recorded instead of weighing, in order to eliminate the weight of the packaging.

Weight was measured using calibrated Alpha 770 scales manufactured by Seca. These scales had a maximum weight limit of 200 kg which was not exceeded during data collection. When weighing waste in bins or containers, the weight of the empty vessel was subtracted from the total weight recorded. Scales were tared before placing any item on them and caution was taken to ensure the item was balanced centrally on the scale in order to obtain an accurate weight as recommended in the standard protocol guidance document (41).

Audit recording sheet development

A draft waste audit recording sheet was adapted from the data collection tool by Reynolds and Mirosa (68) for use in a retail food waste quantification setting (Appendix 5).

Pilot audit

A pilot audit was carried out in one store to trial the methods developed. This audit took place in May 2017. As a result of the pilot audit, methods were adjusted as follows: the level of detail to be recorded; how the separation process would be carried out; and how to obtain the necessary information from retail staff. The draft waste audit recording sheet was also modified in order to increase the efficiency of the data recording process. The final waste audit recording sheet used in the study can be found in Appendix 6.

3.3.2 Interviews with key retail staff

A qualitative interview outline, consisting of 12 semi-structured interview questions, was developed with the aim of understanding the key motivators and barriers identified by retail staff to food waste reduction in New Zealand supermarkets (Appendix 7). The interview questions covered the topics of: general store waste; waste management procedures; potential barriers and motivators to waste reduction; and potential for implementation of future reduction initiatives.

3.3.3 Existing data provided by retailers

Data provided by retailers was used as the primary data source by WRAP (18), thus in this study the researchers requested existing retail food waste data collected by the two retail bodies in New Zealand. However, upon discussion with the retail representatives, it was apparent that this data would not be comprehensive enough (i.e. only available for a small number of stores) to be used as the primary data source. Waste destinations and the definition of food waste varied between the two retail bodies, which further limited the use of the data. Thus, data provided by the retailers was used to compare the onsite food waste audit data collected in this study (i.e. to validate the quantities), but was not used as a primary data source.

3.4 Data Collection

3.4.1 Onsite food waste audits

Prior to each audit, the research team corresponded with store representatives to arrange a convenient date and time for the onsite food waste audit to be carried out. In order to gather data for all waste destinations, audits were planned carefully. In some instances store representatives required the research team to visit the store in advance to make arrangements for the audit day. Each store representative was asked to organise a suitable place for the audit to be conducted with minimal inconvenience to staff.

Store representatives were also asked to provide the approximate collection times for waste directed to each destination for the day of the audit. In order to audit waste over a 24-hour period, stores were asked to hold back waste from the day prior to the audit. The order of weighing each waste destination was dependent on the collection schedule for each store. For example, if bakery product was to be collected at 9:00 hr for food donation; produce at 11:00 hr by a farmer; and protein at 13:00 hr for protein

reprocessing, the waste would be weighed in this order. The research team relied on retail staff to provide information about prior food waste collection times, and thus the 24-hour waste audit timeframe was an approximation. In some instances, it was not possible to collect all the required data in one day. For example, some bins may have already been collected prior to the audit, thus were not available on the day, making it necessary for the research team to return to the store the following day to collect this information.

Due to variation in procedures and schedules within stores, the research team needed to be flexible and adapt to the needs of each store.

Volunteers received training on the day of the audit including an explanation of how the audit was to take place and their duties. The candidate explained how the audit recording sheet was to be used, and the process of separating and weighing food waste. The candidate was present at each audit which minimised inconsistencies in audit processes.

Waste audit protocol

Figure 3.2 outlines the audit process and is described in more detail here:

1. Upon arrival, the research team met with the store representative to be shown a convenient place to carry out the audit and where bins were held around the store. Often this involved the provision of health and safety information, and introductions with department managers who could provide assistance throughout the audit.

Figure 3.2 Retail food waste audit protocol

2. An audit space was set up close to the bin. The audit setup consisted of a small tarpaulin which was laid on the ground, a set of scales, and small bins for waste to be divided in. Some stores provided spare collection bins (i.e. wheelie bins that would be collected by the waste contractor), which were helpful as portions of waste could be transferred into the new bin after weighing.

3. Food going to each destination (i.e. landfill, compost) was weighed separately. For all waste destinations, waste and diverted product were removed from each destination bin (one destination at a time) and emptied onto the tarpaulin for sorting. Food items were separated from non-food items (i.e. polystyrene, plastic, cardboard).

4. Waste and diverted product were divided into food categories (i.e. bakery, fresh fruit). Food was then sorted by hand into product type (i.e. bananas, savoury baking, tinned food, fish).

5. Once separated into piles of product type, the food waste was weighed using tared, calibrated scales. The weight of the container holding the waste was subtracted before recording, or noted next to the measurement to be later deducted.

6. The weight, store ID, date, destination, food category, and product type were recorded on the audit recording sheet (Appendix 6). Any date labels and level of avoidablility (i.e. avoidable and unavoidable) were also recorded.

7. After food had been weighed and recorded it was placed back into the appropriate bin and returned to its storage location. This process was carried out for each waste or diversion destination used by each supermarket. Any mess created during the audit process was then tidied, and appropriate supermarket staff were notified that the audit was complete.

Audits took 5- 6 hours to complete in total. It is important to note that the research team had a pre-planned schedule for each audit, and weighed the contents of each bin systematically.

For the landfill waste destination, special consideration had to be made for health and safety reasons, as non-food items placed in skips were potentially hazardous. At the beginning of each audit the candidate made contact with the store representative to ask whether it was possible for landfill waste to be audited. The majority of stores agreed. However, when this was not possible most stores were able to provide data on what they had 'scanned-out' (i.e. recorded) as waste for the previous 24-hours, so that data on landfill waste could still be collected.

Staff were asked to place landfill waste bags outside the skip. However, if this was not possible due to space restrictions, stores were asked to provide a stepladder to allow the easy retrieval of bags from the skip. Each bag was then passed to the audit volunteer who was standing beside the skip and placed on the tarpaulin. Bags were opened and inspected for the presence of food items. Food was then retrieved from the bags, sorted, weighed, recorded and returned to the skip (steps 3-7). Hi-visibility vests, mesh overalls, gloves and gumboots were worn at all times when auditing landfill waste.

Photographs and written observations were kept throughout the auditing process, in addition to the information recorded on the audit recording sheet. The photographs and observations are not presented in this thesis for confidentiality reasons.

3.4.2 Interviews with key retail staff

Prior to the audit, the research team made contact with one key retail staff member in each store, and invited them to take part in an interview on the day of the audit, or for a

few stores, at a later date. Before each interview, the interviewer informed the retail staff member that anything said in the context of the interview would be treated anonymously. Participants were asked for their permission for a voice recording to be made of the interview and informed that this was only for the purpose of transcribing the interviews. Neither the audio recordings, nor the complete transcribed interviews would be available to anyone outside the research team.

Participants were then asked if they were ready to commence the interview, and advised that they could withdraw at any time, with no disadvantage. The recording device was turned on prior to the interview commencing. The interviewer made handwritten notes throughout the interview to capture key pieces of information mentioned. The interview was approximately 10-15 minutes in duration.

3.4.3 Existing data provided by retailers

Both major retail bodies were contacted by email and asked to provide existing data available on the weight of in-store food waste.

3.5 Data entry and cleaning

3.5.1 Onsite food waste audits

Data from onsite food waste audits were entered into Microsoft Excel on a password-protected computer. Each store was assigned an unique ID number. Data were entered into a separate spreadsheet for each store and triple checked by the candidate against raw data collected during the audits. Data were coded according to the WasteMINZ classifications for food categories and food products (see Figure 3.1 and Appendix 4) (10). These classifications were adhered to as closely as possible, however, eggs were reclassified from the 'Dairy' category to the 'Staple food' category, and dried fruit was re-classified into the category of 'processed fruit', instead of 'staple foods'. Some data

contained weight measurements for products that had been wasted over more than one day; data was adjusted to represent a 24 hour period.

The data cleaning process involved collapsing separately recorded estimates for the same product, directed towards the same waste destination from the same store, to generate one single weight estimate for that product. Two pieces of data were excluded as these products were an anomaly for this store: 364kg of soft drink and 143 kg of dried fruit were inadvertently discovered in one store on the day of the audit. In addition, 128kg of dairy waste for reprocessing was weighed in another store. However, this waste destination was excluded as it was not possible to ascertain how many days this waste represented. Data from all stores were then aggregated to collate estimates for each waste destination, and each food category across the entire dataset.

3.5.2 Interviews with key retail staff

Audio recordings for fourteen interviews were used to transcribe interviews into Microsoft Word by the candidate. Thirteen audio-recordings were made during face-to-face audits, one store provided typed answers to the interview questions, and two interviews were conducted by phone (one interview was recorded and the answers for the other interview were typed during the interview). During transcription, personal identity and store identity were removed and replaced with the corresponding interviewee's unique ID number, as not to disclose confidential information in the reporting of the research. Transcription was carried out by listening and re-listening to each voice recording, and stopping and starting the recording to transcribe the interview. The interviews were transcribed non-verbatim (i.e. um's and ah's were not transcribed, and sentences that were aborted were also not transcribed). The transcribed interviews

were then uploaded into qualitative analysis software package, NVivo Version 11, as Microsoft Word documents for analysis.

3.5.3 Existing data provided by retailers

Both retail bodies provided data on the weight of in-store food waste for some of their stores in the form of Microsoft Excel spreadsheets, with a separate column for food waste recorded for each month. Each spreadsheet was checked for missing data and anomalies, and months with missing data and apparent anomalies were excluded.

3.6 Data analysis

3.6.1 Onsite food waste audits

Data were sorted by waste or diversion destination, and sorted separately by food category, to provide estimates for food directed to each waste or diversion destination and for each food category. Although food waste was recorded for 16 categories, eight categories had ≤1% of total food waste and diversion measured, so were collapsed into 'all other food categories'. Descriptive statistics were used to report quantitative data using Microsoft Excel.

Filimonau and Gherbin conducted a series of interviews with retail store managers (50) and reported that managers believed larger supermarkets generate more food waste than smaller stores (50). Consequently, the data was adjusted for store size (i.e. per square metre of retail space (kg/m^2)).

Inferential statistics were used to estimate retail food waste at a population level. Mean food waste and diverted material calculated from the retail food waste audits was multiplied by the total number of Countdown, PAK'n'SAVE, and New World stores in New Zealand (n=377) and then multiplied by 365 days to generate an estimate for annual

retail food waste in New Zealand. This figure was then compared to international estimates for retail food waste (18, 28), and estimates for household food waste in New Zealand (10). Estimates were calculated for different aspects of the data depending on what the comparison estimate included (i.e. when comparing data from the present study to household food waste, only the food waste sent to landfill was included in the estimate, as household food waste data was only measured for the landfill waste destination).

3.6.2 Interviews with key retail staff

Inductive thematic analysis was used to identify and analyse themes within the interviews with key retail staff. This data-led method of analysis was used to identify codes within the data, rather than using theory to inform the coding structure (theoretical thematic analysis) (69). This approach is commonly used in fields where existing literature is limited, and was therefore appropriate in the context of this study (69). NVivo was used to aid the coding process by assisting with the extraction of sections of text that were then organised under nodes in a Nvivo library. The process outlined by Braun and Clarke was adhered to as closely as possible when conducting qualitative analysis (69). This process involves six phases including: familiarisation with the data, generation of initial codes, collating of codes into themes, reviewing themes, naming and defining themes, and lastly the presentation of key results (69).

The thematic analysis process began by immersion in the data through in-depth reading of interview transcripts, and the documentation of initial codes. The data was fresh in the mind of the candidate from conducting and transcribing the interviews. Re-reading interviews triggered the recollection of observations made, and allowed the candidate to remember the context and impact of statements expressed during interviews.

The entire dataset was scanned for codes relating to the research question, and an initial coding structure was designed. Each interview was then read one-by-one and relevant material from each interview was coded. Additional codes were added as the process progressed. The coding process was iterative and involved constant revision, addition, and checking of codes. The candidate played an active role in the coding process by identifying key patterns in responses which related to the specific research question.

The candidate met with one of the primary supervisors for the study and discussed the coding structure and broader dominant themes. The structure was refined as a result of this discussion. The codes were then organised into overarching themes because of similar ideas and meanings.

As the focus of the qualitative aspect of this research was to identify motivations and barriers for waste reduction, the researchers focused on semantic themes within the dataset. Although it is important to note that data were interpreted within the wider meaning of each statement (i.e. when interviewees mentioned that a lot of waste is produced due to grading of produce), this was interpreted as a barrier to food waste reduction associated with high quality standards.

The aforementioned characteristics of thematic analysis are in line with an essentialist/realist approach to qualitative research, which focuses on theorising motivations as the interviewee articulates them (69). Once the data were organised into themes, the research team began the process of revising and interpreting the broader implications of the identified themes. The final coding structure is presented in Appendix 8**.** Themes were then defined (refer to Table 4.10) and illustrative quotes for each dominant theme extracted for the presentation of results.

For the purposes of this mixed methods study that included both quantitative and qualitative components, it was useful to report the frequency of themes in order to link the quantitative and qualitative parts of the study. A count was taken of how many times each theme was articulated across the entire data set, and by the number of different interviewees that mentioned the theme (i.e. the source of the statement).

3.6.3 Existing data provided by retailers

The research team analysed the data collected in the present study with monthly data provided by the retail bodies. It was only possible to make a direct comparison between one store that was audited and the corresponding data recorded for that store by the retail chain.

4 Results

Data from onsite food waste audits and interviews with key retail staff were obtained for all 16 stores. Existing data from retailers were also obtained. The following chapter summarises results obtained for all three components of the study. Firstly, quantitative results generated from onsite food waste audits will be presented in Section 4.1, with comparisons to existing food waste estimates reported in Section 4.2. Secondly, Section 4.3 will describe the results from the semi-structured interviews with key retail staff. Finally, results from analysis for existing data provided by retailers will be presented in Section 4.4.

4.1 Onsite food waste audits

This section will summarise the demographic variables of participating stores (4.1.1). Data collected for waste directed to each food waste and diversion destination (4.1.2), and food waste and diversion category (4.1.3) will be presented. Food product and trimming waste will also be described (4.1.4), and results for the top ten most common food waste products will then be presented (4.1.5). Finally, comparisons between estimates generated for retail food waste in the present study, international estimates for retail food waste (4.2.1), and estimates for food waste in the New Zealand household sector (4.2.2) will be presented in Section 4.2.

4.1.1 Demographic variables of participating stores

Of the 16 stores that were selected to participate in the study, one store withdrew prior to the audit period commencing and was replaced by another store in the same location. In total 16 onsite food waste audits were carried out. One retail chain did not process protein in-store within the North Island (n=4). Therefore, the estimates for these stores were not comparable to the rest of the sample. In one store (n=1), it was not possible to measure

landfill waste, and thus incomplete data was obtained for this store. Demographic variables for the total sample of stores (n=16) and a subsample of stores (n=11) for which complete data was obtained are displayed in Table 4.1. For confidentiality reasons, demographic variables for each retail body are presented anonymously.

Table 4.1 Demographic variables of participating stores

	Total sample (n=16)		Subsample (n=11)[1]	
	Retail body A (n)	Retail body B (n)	Retail body A (n)	Retail body B (n)
Total number of stores	8	8	4	7
Location				
Auckland	2	2	0	2
Wellington	2	2	0	1
Christchurch	2	2	2	2
Dunedin	2	2	2	2
Stores on a waste minimisation programme	1	5	0	4
Mean retail floor space (m^2)	2,742	2,174	2,752	2,044

[1] Exclusive of one store which did not provide complete data and four stores which processed protein offsite

An equal number of stores were recruited from retail body A and retail body B; two stores in each location, from each retail body. In the total sample, six stores were on an in-store waste minimisation programme. In the subsample, four stores were on a similar programme.

4.1.2 Estimates for food waste and diversion directed to each destination

Weights for food directed to each destination obtained for each store were used to calculate the mean weight per store of food directed to each destination within the total sample (n=16) and the subsample (n=11) for the period of one day. The total sample includes stores with incomplete data, whereas the subsample only contains stores with complete data. The mean daily weight, standard deviation (SD), and percentage (%) of

the total weight of waste and diverted product directed to each destination are presented in Table 4.2 (for total daily weight and ranges, see Supplementary Table 1 in Appendix 9).

Table 4.2 The mean daily amount (kg) and distribution (%) of retail food waste and diverted product to each destination

	Total sample (n=16)		Subsample[1] (n=11)	
Destination	Mean ± SD (kg)	Percentage (%)[2]	Mean ± SD (kg)	Percentage (%)
Animal feed	146 ± 183	37	204 ± 195	46
Landfill	103 ± 82	25	101 ± 80	23
Food donation	70 ± 60	18	67 ± 67	15
Protein reprocessing	48 ± 41	12	63 ± 36	14
Compost	33 ± 93	8	4 ± 14	1

[1] Exclusive of one store which did not provide complete data and four stores which processed protein offsite
[2] Percentages do not add to 100 due to rounding

When comparing the total sample with the subsample, the amount of waste sent to landfill (103 vs 101 kg/day) and the amount diverted to food donation (70 vs 67 kg/day) were similar between samples. In this study, large inter-store variation was observed, as some stores did not utilise all destinations measured. For example, one store diverted 0 kg/day to animal feed while another store diverted 602 kg/day to animal feed (see Supplementary Table 1 in Appendix 9).

Animal feed made up a larger percentage of total food waste and diverted product in the subsample than in the total sample. However, a greater proportion of food was directed to landfill, food donation, and compost in the total sample, than the subsample. In the total sample, 8% of waste and diverted product was directed to compost, which was higher than the 1% in the subsample. The lower percentage in the subsample can be explained

by the exclusion of two stores from the total sample that were highly reliant on the compost food waste destination. The percentage of total retail food waste directed to protein reprocessing in the total sample was less than in the subsample, due to the absence of this waste destination in four stores that were included in the total sample.

From this point forward all estimates are based on the subsample of (n=11) as the data collected in these audits were complete and directly comparable. This will be referred to as the sample.

Table 4.3 presents the sample results for waste and diverted product distributed to each destination adjusted for retail floor space (i.e. the area of the store accessible to customers).

Table 4.3 Weight (kg/m^2) and percentage (%) of food waste and diversion to each destination, adjusted for retail floor area (m^2) (n=11)

Destination	Mean (kg/m^2)	Percentage (%)[1]
Animal feed	0.088 ± 0.067	44
Landfill	0.046 ± 0.035	23
Food donation	0.032 ± 0.032	16
Protein reprocessing	0.029 ± 0.016	15
Compost	0.001 ± 0.005	1

[1] Percentages do not add to 100 due to rounding

Adjusting for retail floor area did not alter the percentage of food sent to each waste or diversion destination by more than two percent compared to the subsample (n=11) (Table 4.2), therefore, unadjusted data has been reported in this thesis.

4.1.3 Estimates for food categories directed to each destination

Table 4.4 presents data for the total weight of food measured for each of the eight food categories. Data is presented separately for food that was directed to **food waste**

destinations (i.e. landfill, protein reprocessing, and compost**)**, to **animal feed**, to **food donation,** and the **total weight** of all food measured during onsite audits separately (refer to Section 3.3.1 for detail on the way destinations have been grouped). Data are presented in this way so that food directed to food waste destinations (i.e. landfill, protein reprocessing and compost) can be analysed separately from food directed to food diversion destinations (food donation and animal feed), as well as an aggregated total of all food waste and diverted product measured during the 11 onsite food waste audits.

For food directed to destinations considered as food waste, meat and fish made up 50% of total food waste. Dairy was the next most dominant food category, contributing 14% to total food waste, followed by 12% for bakery. For all food not sold or used at a retail level (i.e. total), fresh vegetables contributed to 27% percent of the total, bakery contributed to 23%, meat and fish 19%, fruit 17%, and dairy 6%.

Figure 4.2 depicts the data presented in Table 4.4, with food waste destinations separated into landfill, protein reprocessing, and compost. See Supplementary Table 2 in Appendix 9 for the weights for each food category directed to each waste or diversion destination, and the percentage of product (food that was intended to be sold to customers) and trimmings (the portion of the food removed prior to sale and are not intended to be sold). Across all 11 stores, a total of 33kg of fresh fruit and 15kg of fresh vegetables were sent to compost over a 24-hour period within the sample. A total of 698kg of meat and fish were sent to protein reprocessing, 100% of this was made up of meat and fish trimmings, removed from the product prior to sale. Of food diverted to food donation 387kg (53%) was bakery, whereas 493kg (22%) of food sent to animal feed was bakery.

The amounts of fresh fruit and vegetables directed to food donation were relatively small 99kg (13%) and 172kg (23%) respectively, compared to fresh fruit and vegetables sent to

animal feed, 669kg (30%) and 1050kg (47%) respectively. The research team observed that much of the fresh fruit, and some of the fresh vegetable product going to animal feed was in fact good enough for human consumption. Of the fresh vegetables sent to animal feed 14% were product and 86% were trimmings that were removed from the vegetables prior to sale.

The landfill waste destination had the most variation in food categories. The food category that contributed the most to landfill food waste was dairy, which amounted to 257kg, and contributed to 23% of total food waste sent to landfill. Bakery, and meat and fish products contributed 21% each to total food waste directed to landfill, or 230kg and 232kg, respectively. Of the meat and fish product sent to landfill 75% was product and 25% was trimmings removed from the food before sale. An observation made during the onsite food waste audits was that proportionally high amounts of organic or premium dairy products, bakery, and meat were wasted and directed to landfill.

Table 4.4 Weight (kg) and percentage (%) of food categories to total food waste and diversion directed to food waste and diversion destinations (n=11)

Food category	Food waste[1]		Animal feed		Food donation		Total	
	Weight (kg)	Percentage (%)[2]	Weight (kg)	Percentage (%)	Weight (kg)	Percentage (%)	Weight (kg)	Percentage (%)
Fresh vegetables	79	4	1050	47	172	23	1301	27
Bakery	230	12	493	22	387	53	1110	23
Meat and fish	930	50	0	0	0	0	930	19
Fresh fruit	50	3	669	30	99	13	818	17
Dairy	257	14	16	1	5	1	278	6
Staple foods	124	7	9	0	36	5	169	3
Drinks (non-dairy)	83	4	0	0	31	4	114	2
All other food categories[3]	108	6	3	0	7	1	118	2
Total	1861	100	2240	100	737	100	4838	99

[1] Food waste includes landfill, protein reprocessing and compost
[2] Percentages do not add to 100 due to rounding
[3] All other food categories include: Pre-prepared foods, snack foods, confectionery, desserts, processed fruit, processed vegetables, condiments, fats, and other.

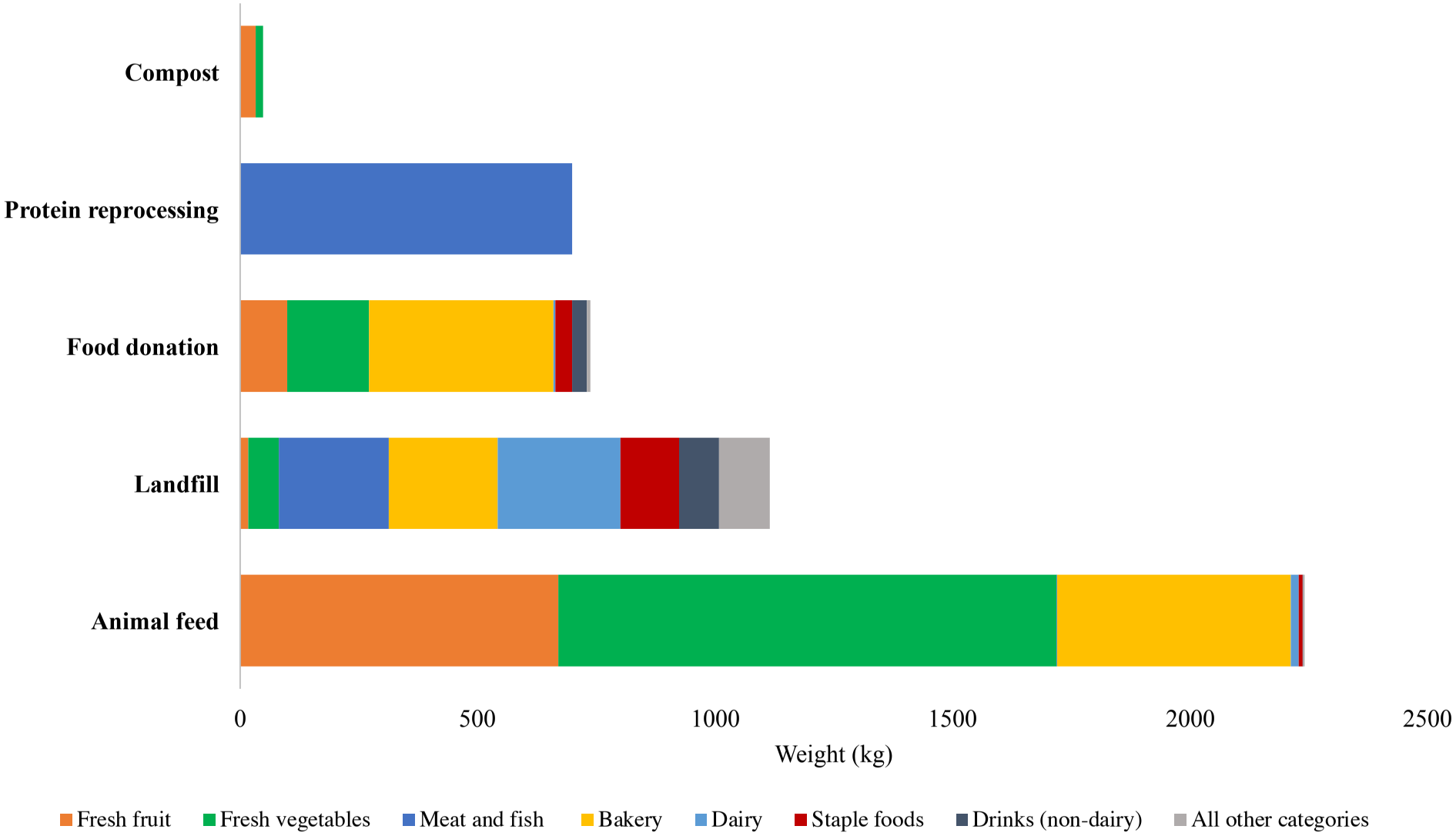


Figure 4.1 Weight (kg) of food categories diverted to food waste or diversion destinations (n=11)

4.1.4 Percentages of food product and trimmings for food categories

Figure 4.1 presents the percentage of food product and of trimmings that were wasted or diverted.

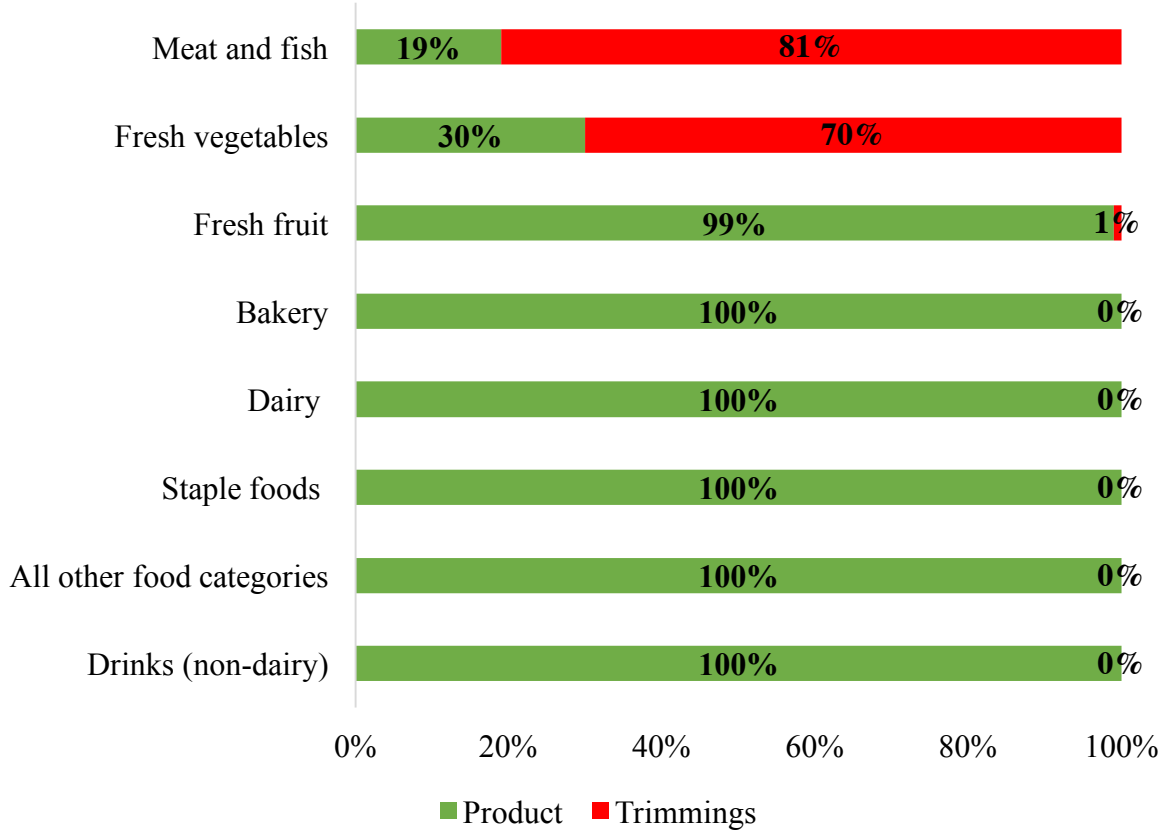


Figure 4.2 Percentage (%) of food product and food trimmings wasted or diverted for each food category (n=11)

Fresh vegetables, and meat and fish were two food categories which underwent extensive trimming in-store prior to sale (70% and 81%, respectively). As a result, much of the food waste and diverted product for these two food categories were trimmings. Fruit trimming is uncommon at a retail level, and thus only 1% of total fresh fruit wasted or diverted was trimmings. For all other food categories, 100% of food wasted or diverted was intended to be sold.

4.1.5 The most common food waste products at a retail level

Of all product not sold or used at a retail level, the most common food waste and diversion products are presented in Table 4.5**.**

Table 4.5 Top 10 food waste and diversion products at a retail level, by weight (kg) and percentage (%) contribution to total retail food waste (n=11)

Ranking	Food product	Total weight (kg)	Percentage of total retail food waste (%)
1	Vegetable trimmings	912	19
2	Meat and fish trimmings	755	16
3	Bread	722	15
4	Citrus	380	8
5	Milk and flavoured milk	154	3
6	Savoury baked goods[1]	150	3
7	Potatoes	120	2
8	Beverages[2]	114	2
9	Bananas	111	2
10	Sweet baked goods[3]	105	2

[1]Savoury baked goods include bakery items such as pizza buns, garlic bread, scrolls, and cheese scones
[2]Beverages include all drinks (i.e. juice, fizzy drinks), excluding dairy or dairy substitute drinks (i.e. almond milk)
[3]Sweet baked goods include items such as muffins, sweet scones, cakes, doughnuts, slices, sweet pastries, fruit pies, and Chelsea buns

Vegetable trimmings, and meat and fish trimmings were the top two food waste and diversion products by weight measured in the onsite food waste audits not intended to be sold to consumers. Bread represented 15% of total daily food waste and diverted product measured, and was the largest contributor to bakery waste and diversion. All bread was intended for sale, and thus bread was the most commonly wasted or diverted food product at a retail level intended for sale. Citrus fruit represented 8% of total food waste and

diverted product measured, and was the most commonly wasted or diverted fresh fruit product. Milk and flavoured milk drinks contributed to 3% of total food waste and diverted product, and were the largest contributor to dairy food waste and diversion.

4.2 Estimates for retail food waste in New Zealand

Sample data (n=11) was scaled up to estimate retail food waste at a national level for all Countdown, PAK'n'SAVE and New World stores in New Zealand (n=377). It is important to note that the following three tables present different aspects of retail food waste. Table 4.6 presents both food waste and food diversion (4.2.1), Table 4.7 presents food waste only, and excludes food diversion (4.2.1), and Table 4.8 presents only food waste directed to landfill (4.2.2).

4.2.1 Retail food waste for New Zealand compared to international estimates

Table 4.6 presents comparisons between estimates for retail food waste and diversion in New Zealand, and retail food waste and diversion estimates generated by the Waste and Resources Action Programme (WRAP) for the UK retail sector (18).

Table 4.6 Estimated total (tonnes) annual and per capita (kg/person/year) retail food waste and diversion in New Zealand and the UK

	Mean retail **food waste and diversion** in New Zealand[1]	Mean for retail **food waste and diversion** in UK[2]
Total food waste and diversion per annum (t)	60,500	240,000
Annual food waste per capita[3] (kg/person/year)	13	4

[1]Scaled using data from the present study for food waste, animal feed and food donation for all Countdown, PAK'n'SAVE, and New World stores (n=377)
[2]WRAP estimates for food waste, animal feed and food donation in the UK retail sector (18)
[3]Estimated using census data (65)

These comparisons include all food waste, food diverted to animal feed, and food diverted to food donation. The UK are producing approximately one third of the retail food waste and diversion per capita per year that New Zealand is estimated to produce.

Table 4.7 reports comparisons between estimates for total food waste per annum for the New Zealand retail sector, and FUSIONS estimates for the European retail sector (28). This table only reports food waste, therefore food diversion (i.e. any food sent to food donation or to animal feed) is excluded.

Table 4.7 Estimated total (tonnes) annual and per capita (kg/person/year) retail food waste in New Zealand and selected European Union countries

	Mean retail **food waste**[1] in New Zealand[2]	Mean for retail **food waste** in selected EU countries[3]
Total food waste per annum (t)	23,300	1,675,700
Annual food waste per capita[4] (kg/person/year)	5	9 (4-30)[5]

[1]Food waste excludes food donation and food to animal feed
[2]Scaled using data from the present study for landfill, protein reprocessing and compost for all Countdown, PAK'n'SAVE, and New World stores (n=377)
[3]FUSIONS estimates for food waste in Europe, exclusive of food donation and animal feed (28)
[4]Estimated using census data (65)
[5]Mean (range)

It was estimated that approximately 23,000 tonnes of food waste is generated in the sector per annum in New Zealand, which equates to 5kg per head of capita per year. In contrast, estimates generated by FUSIONS for retail food waste in Europe equate to approximately 9kg/person/year and vary greatly between countries, with some countries producing 4kg/person/year and others producing 30kg/person/year (28).

4.2.2 Food waste directed to landfill at retail and household levels in New Zealand

Food waste estimates for the New Zealand household sector are based on the amount of food waste destined for landfill. Table 4.8 presents estimated annual retail and household food waste directed to landfill in New Zealand (10).

Table 4.8 Estimated total (tonnes) annual and per capita (kg/person/year) food waste directed to landfill for the New Zealand retail and household sectors

	Mean for retail food waste in New Zealand[1]	Mean household food waste in New Zealand[2]
Total food waste to landfill per annum (t)	14,000	122,500
Annual food waste to landfill per capita[3] (kg/person/year)	3	29

[1] Scaled using data from the present study for landfill food waste to represent all Countdown, PAK'n'SAVE, and New World stores (n=377)
[2] WasteMINZ National Food Waste Prevention Project estimates for landfill food waste (10)
[3] Estimated using census data (65)

It was estimated that food waste sent to landfill at the retail level in New Zealand is 10 times less per head of capita per year than food waste at a household level.

4.3 Interviews with key retail staff

This section of the results chapter will present the qualitative results of the study gathered from semi-structured interviews with key retail staff members in stores. Firstly, demographic variables of the interviewees will be presented (4.3.1). This will be followed by a description of interviewee's perceived satisfaction with in-store waste management practices (4.3.2). Thematic results will then be presented for key motivators and barriers to further food waste reduction (4.3.3). Lastly, how typical interviewees viewed the audited food waste will be described (4.3.4)

4.3.1 Demographic variables of interview participants

Of the 16 retail staff recruited to participate in the interviews all agreed to take part, and complete data was obtained from all interviewees. The demographic characteristics of interviewees are presented in Table 4.9**.** All interviewees were either in managerial roles or were store owners, however, no information about level of experience was obtained.

Table 4.9 Demographic variables of key retail staff interviewed (n=16)

Number of interviewees (n=16)	Retail body A (n)	Retail body B (n)
Total	8	8
Location		
Auckland	2	2
Wellington	2	2
Christchurch	2	2
Dunedin	2	2
On a waste minimisation programme	1	5

Interviewees names were removed from their responses and replaced with an interviewee number (Int.), ranging from (Int. 1) to (Int. 16)

4.3.2 Perceived satisfaction with food waste management in-store

Comments made by each interviewee on their perceived satisfaction with the way waste was managed in their store. Of the 16 staff interviewed, 11 interviewees (69%) commented on their satisfaction with current waste management practices in-store.

> "I think we have pretty good controls on most of it, we focus on it quite heavily at the moment, and the more we can give away to the likes of food rescue then the happier we are". (Int. 6)

Many interviewees also acknowledged improvements that had been made to their food waste management practices overtime which contributed to this sense of satisfaction. One

participant commented “I think we have done a pretty good job, in the last three months we have gone from … two full pig bins, he’s lucky now to get one bin”. (Int. 6)

A number of participants who believed they had good practices in-store also identified that managing waste is a process where continual improvement can be made, mentioning “is it ever 100% right? No, it’s not, but at the end of the day if we’re working towards it, it’s a lot better than saying whatever”. (Int. 5)

On the other hand, 31% of interviewees (i.e. 5/16 interviewees) mentioned the need to focus on better managing food waste, commenting “I think there is definitely a lot more that we could do … we’re probably not doing that great with how we manage our waste at the moment”. (Int. 12) Some interviewees commented on potential means of improvement for the future. For example, one store identified that “shredded chicken is the number one dump-line and mark down line. So we will be using the chicken production planner to make sure we cook what we need”. (Int. 8)

4.3.3 Thematic results

During the coding process nine dominant themes were identified across the entire dataset. These themes were separated into two broad categories: motivators for future food waste reduction; and barriers to further food waste reduction. Themes that were classified as motivators were: protecting the environment, increasing profitability of the business, caring for the community, and doing the ‘right’ thing. Themes that were identified as barriers to further food waste reduction were: training and educating people, food safety concerns, quality standards and expectations, waste diversion avenues and capacity, and resource availability.

Table 4.10 displays the definitions for the nine themes identified.

Table 4.10 Definitions of themes identified

Theme	Definition
Motivators	
Protecting the environment	Expression of care for the environment and diverting waste from landfill.
Increasing profit	Increasing profits by reducing costs associated with food waste disposal and losses in potential revenue
Caring for the community	Donating food to local charities and farmers is perceived by retailers as caring for the community.
Doing the 'right' thing	Managing waste in a socially responsible way to show customers and staff that the business is dedicated to doing the 'right' thing.
Barriers	
Training and educating people	Lack of education provided to staff about the importance of reducing and managing food waste appropriately, and insufficient training to provide staff with skills to carry out procedures.
Food safety concerns	Concerns for causing sickness, and the repercussions for their business from donating food to people or farmers that could potentially be unsafe.
Quality standards and expectations	Quality expectations maintained by both the business and by customers cause excess waste of product.
Waste diversion avenues and capacity	The lack of diversion avenues available, and the lack of knowledge of diversion avenues that exist. As well as the ability for organisations that do exist to handle the quantity of food that could potentially be donated.
Resource availability	The lack of resources available to stores that would allow for the improvement of waste management practices in-store.

Motivators for food waste reduction

The frequency (i.e. number of times the theme was mentioned) and source (i.e. the number of participants that mentioned the theme) are displayed in Table 4.11.

Table 4.11 Frequency and source that each motivator for food waste reduction was articulated across the data set (n=16)

	Frequency (n)[1]	Source (n)[2]
Protect the environment	22	9
Increase profitability	19	9
Caring for community	14	8
Doing the 'right' thing	11	4

[1]Number of times the theme was articulated across the entire data set
[2]Number of interviewees that articulated the theme

Protecting the environment was the most prevalent motivator for in-store food waste reduction. Increasing business profitability by reducing food waste was the second most frequently mentioned theme across the dataset, and was mentioned by over half of the interviewees. Caring for the community, and finally doing the 'right' thing were mentioned by half, and one quarter, of interviewees respectively, and articulated more than 10 times across the entire dataset.

Protecting the environment

Protecting the environment was one of the main motivations identified by retail staff for further reducing food waste in-store. In the context of the interviews, comments made about motivation to reduce waste to landfill were interpreted as environmental protection motivators. For example, an interviewee commented that a benefit associated with food

waste minimisation was to "reduce the impact on the environment with total waste going to landfill". (Int. 7)

One interviewee mentioned the motivation to minimise in-store food waste by "having a better footprint on the environment" (Int.12) and acknowledged that "there is a lot of waste that goes to landfill and a lot of that doesn't need to". (Int. 12) The notion that reducing the amount of waste destined to landfill will in turn benefit the environment was a driver identified by retailers to improve their waste management practices in targeted ways.

The motivation of reducing food waste to protect the environment raised a sense of commitment and responsibility in some retailers for taking care of the environment. One retailer commented that "…if there was something I could do with any of the food waste I would do it, because we are big into recycling. Anything that can be diverted from landfill, we are prepared to do". (Int. 16)

The motivation of leading by example in the way that retailers take care of the environment by managing their waste was also emphasised. One interviewee stated that "..if we're going to teach our colleagues and our children what we want to do moving forward … you want to start off the way you want to carry on, and that's doing right by the environment". (Int.5)

Increasing profitability of the business

The theme of profit was dominant throughout the dataset. Retailers were motivated to reduce waste as sending food for landfill is costly for the business.

> Obviously there's a profit side to it as well, obviously from a business point of view you are charged on the volume that you send, so the more you recycle, and save, and make less, obviously the more profitable it is for the business. (Int. 7)

Retailers also acknowledged the financial losses incurred from the purchase of wasted product "because it still cost … to get that stuff". (Int. 14) Therefore, "if you don't have any wasted product then it's not coming off your bottom line". (Int.14)

Retailers identified that the ability to sell a product, even at a reduced cost, was a benefit. Any food that was able to be sold instead of wasted to generate profit was seen by retailers as a motivation to prevent food from being discarded. One interviewee commented that "if we can manage to sell something slightly cheaper instead of putting it in the waste then it becomes more profitable for us". (Int. 1)

Although retailers acknowledged the benefit of reducing the price of stock in order to cover the cost of purchase, and prevent the expense of wasting the product, the importance of generating profit to ensure the business is viable was emphasised. One store no longer mark down (i.e. reduce the price) bakery items. This was implemented to identify where their processes needed to change in order to reduce waste, and subsequently increase profits generated for the business. An increased focus on reducing food waste was seen to have positive impacts on profit.

> Traditionally bakers will turn up at 2 O'clock in the morning and there will be nothing left in their case and they think 'that's great, we've sold it all'. But they wouldn't have any idea how much we have marked down the night before to sell it at a reduced price. So now that we don't mark it down, what they see is what's actually left from full price sales. So now we are only producing for what we can

> sell. So, our total dumps in bakery have gone from about $1200 a day to really under less than $300. (Int.6)

Not only are retailers motivated by the cost savings associated with food waste reduction, but also by the increased profits from selling as much product as possible, both factors of which contribute to the overall profitability of the business.

Caring for the community and doing the 'right' thing

The next two motivators for reducing food waste relate to the reduction of waste being sent to landfill, rather than reducing the physical quantity of food waste produced. Retailers tended to emphasise the importance of food waste diversion in the context of mentioning the motivators of caring for the community and doing the right thing.

Caring for the community

Retailers appeared to be motivated to reduce their food waste sent to landfill through donating food to charities. Being able to care for the community by repurposing food waste was a dominant theme throughout the dataset. It was observed during in-store food waste audits that food donation was a popular avenue to divert food that was deemed by retailers to be unsaleable.

A sense of pride and satisfaction experienced by retailers for being able to donate food was apparent, one interviewee stated that "the more we can give away to the likes of food rescue, then the happier we are". (Int. 6)

> I too am a citizen of this planet, I care, my team do care, we actually take a lot of pride in how much we divert … we literally divert tonnes of food to the local community. We are really proud of this achievement. We do support it, it would

> be the easiest thing in the world to throw it in the bin, there is actually effort involved in not throwing it in the bin, but we definitely see the value in it. (Int.2)

Retailers were motivated by the prospect of caring for the community by diverting as much food as possible to people and "knowing that it's going to a good cause, especially Salvation Army. It's good to look after these charities, they're all doing good." (Int. 4) Retailers were empowered by their ability to do something useful with their food waste and support local charities that in turn support the community.

Retailers recognised that a lot more of the food that is wasted at a retail level could go to feeding people, and therefore, that they have the ability to divert more to the community.

> I feel that the breads at the end of the day don't necessarily need to go to the pigs, they could go to people who need it. There's certain food that does get thrown in the skip that I still think is fit for human consumption. (Int. 16)

This ability to identify areas for improvement in waste management practices, to ensure that unsaleable food is going to the best place possible, shows that this desire to help the community has encouraged retailers to reflect on ways in which they can better manage their waste.

Doing the 'right' thing

Another key motivator identified by retail staff to reduce food waste was to do the 'right' thing. Doing "the right thing by customers" and the "right thing as a business" were both key components of this. (Int.5) Retailers identified that being "seen to do the right thing" was important too. (Int.5) It was mentioned that doing the 'right' thing can lead to better food waste management practices innately. If they as retailers are doing the right thing, then the flow on effects are likely to be positive.

> We are morally obliged to probably do the 'right' thing. That kind of goes hand-in-hand that if we're doing the 'right' thing as a business, our shrink and wastage will come into line as well. (Int. 5)

It was also recognised that as retailers it was important to "make sure that … [they] believe that [they're] doing the 'right' thing as well". (Int. 5) This intrinsic motivation to do better in terms of food waste reduction was dominant throughout the dataset, and reinforced the responsibility and sense of commitment retailers expressed for reducing their food waste.

Barriers to further food waste reduction

Training and educating people was the barrier articulated the greatest number of times, and by three quarters of interviewees, as presented in Table 4.12.

Table 4.12 Frequency and source that each barrier to further food waste reduction was articulated across the data set (n=16)

	Frequency (n)[1]	Source (n)[2]
Training and educating people	30	12
Food safety concerns	22	10
Quality standards	18	8
Diversion avenues and capacity	17	6
Resource availability	10	5

[1]Number of times the theme was articulated across the entire data set
[2]Number of interviewees that articulated the theme

The barrier articulated the most frequently thereafter was food safety concerns for food donation, diversion, and sale of product to customers. This was followed by the quality standards which products must meet to remain on the supermarket shelves. The diversion avenues available for stores to divert food waste from landfill, and the capacity of these organisations to handle and process the quantity of food, was mentioned as another dominant barrier to further food waste reduction. Finally, lack of availability of resources to aid in waste management procedures was identified as a significant theme throughout the dataset, mentioned by one third of participants.

Training and educating people

Training and educating people was the most significant barrier identified to further food waste reduction by the retail staff interviewed. Emphasis was placed on obtaining buy-in from staff in terms of responsibly dealing with waste.

> I think the biggest barrier of any kind of system that we try to implement is the people side of it. People being on board and making sure that we are doing it for the right reasons, it's not just about making money, it's about the environment as well. (Int. 5)

In terms of training, the ability of staff to follow processes that exist in-store was highlighted as a contributing factor to further prevention of food waste. Many retailers commented that they have waste management systems in place. However, "the biggest challenge would be [the] team not using the process correctly…What we have in place has worked and does work when used correctly. (Int. 1)

Retailers also mentioned the negative consequences in terms of increased food waste production that can result from insufficient training of staff.

> If you get someone new and they don't understand our training patterns, then they could potentially over order, and if it's fresh product, it's going to land in the bin because there is only so much we can give away. (Int. 2)

The need for continual training and education in relation to waste management practices was also highlighted. It was suggested that training should be an ongoing process that is regularly implemented.

> I think the biggest thing we have to look at is training. So, if the training is to a high standard, and things don't happen overnight, so just every single day, that steady flow of seeing that everything moves in the right direction that would be a way towards changing. (Int. 13)

In terms of education, retailers identified that a lack of knowledge about how things could be done better as a significant barrier to making the effort to reduce food waste in-store. It was also acknowledged that leadership is important in transferring this knowledge to staff and driving processes in store.

> …the knowledge of how it could be done better, having someone I guess that's willing to implement that. At the moment there isn't really anyone in-store that's got any motivation I guess, to say 'we can do better with this, let's do better' and then put a bit of effort in. (Int. 12)

Retailers provided some suggestions that could help to overcome barriers to food waste reduction in the future. It was mentioned that the more informed people are about the benefits of food waste diversion and reduction, the more motivated they will be to put effort in.

> Research [is needed] into what are the outcomes of us putting more time and effort into waste management in-store … I think that we could easily tell staff, 'look the benefits outweigh your time and effort'. (Int. 15)

It was commented that overcoming the barrier of knowledge is likely to bring about success in terms of further food waste reduction. Creating a mindset shift and a knowledge of how waste can be better managed was a suggested method for tackling this barrier.

> The idea of knowledge. As soon as an individual has a knowledge of 'this just is not going to be thrown away and this can be used or broken down into different areas', then that's the pathway forward instead of standing still. (Int. 13)

It was also mentioned that targeted education specific to food waste reduction could increase awareness for better managing and controlling waste. One interviewee commented that "educating, or working on a programme…where there's a category for waste that hones in on what we're throwing out" (Int. 13) could be a useful improvement to their current systems.

Food safety concerns

Concerns about food safety when diverting food waste to animals or charities was another major barrier identified to further food waste reduction. Retailers argued that they tend to be more cautious when it comes to food safety, as the repercussions of causing sickness could result in negative consequences for the business. This cautiousness can be translated into a barrier, preventing people from diverting food waste over sending waste to landfill. One interviewee stated that "I would rather it be thrown away than someone get sick…obviously we don't want to hurt people, but we could be a headline as well". (Int. 9)

> In the past, we have had farmers that have been picking up bread and milk and things like that. We've got to be careful, at what point can that come back to the business. So, if [the farmers] are feeding it to their animals and their animals got sick, how does that affect us? So, you're trying to do the right thing but it kind of comes back. (Int. 5)

Retailers acknowledged that much of the waste that goes to landfill could be diverted if it weren't for the barrier of concerns for food safety. The food safety standards maintained by the retail bodies themselves to protect customers govern the way that food is dealt with and determine the fate of products that have past their best before and use by dates.

> We could keep things on the shelf to sell. In our deli department, we could cook products on their best before date because that's a quality issue, but … our head owner puts best before dates and expiry dates as the same thing. (Int. 15)

It was observed during onsite audits, that a large amount of food was discarded before it had reached the date label on the package, and most often discarded items had a best before, and not a use by date.

Quality standards and expectations

Another barrier identified to food waste reduction was the quality standards maintained for food on the shelves of supermarkets, and the notion that things need to be taken off if they are not up to the "100% quality factor". (Int. 15) Many retailers commented that customers expect visually perfect produce, that "customers shop with their eyes". (Int. 2) Therefore, staff must grade stock to a very high standard, which results in imperfect product being wasted. Retailers feared that customers would be dissatisfied with the standard of product if imperfect food remained on the shelves and that this may deter customers from purchasing produce from the store all together.

> It would be facetious for me to blame customers for how hard we have to grade produce, but the reality is that New Zealand shoppers have got very high expectations about what 'fresh' looks like. They always seem surprised at what we have to throw away but the reality is, the reason why we throw it away is because if we don't throw it away, they won't buy any of our produce, it's a vicious circle. (Int. 2)

The perception of quality held by the retail bodies was also highlighted as a contributing factor to excess waste. Staff are trained to grade produce in particular to a very high standard, to maintain the image of having good quality produce. These strict quality standards were identified by retail staff as contributing to an increased rate of disposal of fresh products. In store, it was observed that a large amount of produce, in particular fruit, had been removed from shelves due to blemishes, or slight colour changes, yet these items were perfectly edible.

> Produce is probably our biggest focus area at the moment. We've got pretty high standards throughout the company for quality, so we grade three times a day, so there's a pretty wide variety of stuff that will be taken off. (Int. 6)

Overall, whether driven by the retailer or by customers, the demand for top quality product in-store was an extremely strong barrier to reducing food waste. One interviewee commented that "there will always be produce that, unfortunately, perfectly fit for human consumption, goes in the bin. It's just the nature of retail". (Int. 2)

Retailers believed that even having lower quality items available would cause waste, as they believed that customers would opt for the items that have a better perceived quality. That "if [customer's] are looking at, as I said, spotty bananas, or meat that is slightly

browning, or bread that is squashed, they're not necessarily going to buy that over something that looks 100%". (Int. 15)

Food waste diversion avenues and capacity

The availability of options for retailers to divert food waste away from landfill and the ability of these organisations or businesses to deal with the volume of food made available to them has been identified as a significant barrier to further food waste reduction.

Many interviewees commented that they would like to donate more food than they are doing already. However, retailers have little control over the product that organisations are willing to take, and the diversion avenues available in their area.

> The willingness for people to actually take product off us … unfortunately that means that anything the pig farmer doesn't take and the food rescue people don't take has to go in the bin. There is no option for compost, which isn't ideal. (Int. 2)

The volume of food that had the potential to be donated to food rescue charities was so significant that the charities cannot take everything that is made available to them. From the retailers' perspective "there is only so much bread that we can use to make garlic bread. If [the food rescue organisation] doesn't take it, it actually goes in the bin". (Int. 2)

One observation made throughout the auditing process was that retailers made an effort to use as much broken, damaged or poorer quality product within their service deli and bakery departments. As mentioned above, older bread is often used to make garlic bread. Brown bananas are used in the bakery, grocery items with split packaging, dented cans and older meat are often used to create ready-to-eat food that can be sold to customers.

In relation to the avenues available to divert food from landfill, there appears to be a lack of knowledge around what diversion avenues exist. One interviewee questioned "what do I do with the dairy product?" (Int. 16). Supermarket staff may be unaware of some of the diversion options that are available in their area, with one retailer commenting that waste from "butchery and seafood, [we] can't do anything [with that]" (Int. 10).

Resource availability

Retailers identified that resources, in particular time, space, and manpower are barriers to being able to further reduce food waste in-store. "Time, space, that's the key areas, and who controls it. What are the drivers? Who drives it?". (Int. 6)

The research team observed during audits that staff needed to work to tight schedules and back of store space can be limited.

> We are all under time pressure at the moment, so if there are more processes added to our current processes then that can then create … more time for our team to have to go and do it. (Int. 6)

It was mentioned by retailers that a process must be simple and quick to be worthwhile to implement. Due to limited resources, it is crucial that waste management processes do not significantly add to the staff workload, or take up large amounts of space.

> Sometimes if it's too much work, if someone suggested we have to unwrap a whole lot of things, or do a whole lot of stuff, if it was too much work, we wouldn't do it because we just don't have time. (Int. 14)

4.3.4 Typicality of food waste

Within each semi-structured interview one question concerning the typicality, amount, and type of food waste generated on the day of the audit was asked. Overall, retailers believed that the quantity of waste produced is relatively constant over time due to the

predictable and consistent nature of the retail environment. One participant commented "we have the same amount of customers each week and we are producing the same amount of products, especially in the fresh food departments… I think on a weekly basis it wouldn't [vary] that much". (*Int. 15*)

Of the 16 stores that participated in onsite food waste audits and interviews, 14 interviewees commented that the waste observed on the day of the audit was typical of usual waste, or that their waste in general was "very typical, it doesn't really change". (*Int. 14*)

One interviewee mentioned seasonality as a contributing factor to variation in food waste. Highlighting the waste due to produce grading (i.e. removal of imperfect product) that occurs in the summer.

> I guess you have to take seasonality into account. In the height of summer when we have a lot of stock, stone fruit, depending on the product can have a lot of waste from grading. (*Int. 2*)

It was concluded however, that seasonality affects the type of product that is wasted rather than the overall quantity of food waste.

> Generally, it evens out as sales are higher in summer … I wouldn't say there are huge troughs and waves. We have the same contract with the refuse people, so it's not as if we get them coming more often at certain times during the year, it's just set times. (*Int. 2*)

It was also acknowledged that public holidays, promotions, and weather spikes can alter waste patterns. Two interviewees commented that allocation of a large amount of product, or short dated product can lead to increased waste, stating that "It's pretty same-

same mostly, unless there's been an allocation of something, and the date was really short, and we can't get rid of it". (*Int. 4*)

Although under certain circumstances the amount or type of food waste produced can increase or decrease, the majority of participants believed that levels of food waste instore were consistent.

4.4 Existing retail food waste data

Due to the sensitive nature of data specific to each retail body, and for confidentiality reasons, it is not possible to report exact figures for pre-existing food waste data collected by stores in this thesis. When comparing the data for retail food waste in this study with the data provided by the retailers, estimates for the quantity of retail food waste were similar. The research team were able to ascertain that the present study's estimate for retail food waste was within approximately 92% of average daily food waste generated over a 7-month period in the same store. Based on comparison with data obtained in this study with data provided by the retail bodies, a single 24-hour onsite food waste audit for each store at one time-point appeared to be a good proxy for usual waste and appropriate measure for usual waste behaviours. Although the results appear to be similar, definitive conclusions cannot be drawn as only data for one audited store was able to be compared to the data for that store provided by the retail body. Currently, existing retail food waste data collected by stores has limited use due to differences in the definition of food waste as well as missing data, and is not robust enough to use for food waste monitoring by the sector.

5 Discussion

This study was the first of its kind to quantify retail food waste in New Zealand. By comparing in-store food waste data with data provided by retailers, and analysing the qualitative interviews, a one-day audit was able to estimate typical food waste in each store. Overall, the results obtained in the study paint New Zealand retailers in a positive light in the way they manage in-store food waste. This chapter will discuss the key quantitative results presented in the thesis (Section 5.1). It will also comment on the use of the food waste hierarchy in the retail sector (Section 5.2) and the appropriateness of current definitions for food waste (Section 5.3). The estimates for retail food waste in New Zealand will be discussed in regards to international retail food waste quantities (Section 5.4) and national estimates for household food waste (Section 5.5). The qualitative results of the research will then be addressed in Section 5.6. Finally, some strengths and limitations of the study will be presented in Section 5.7, recommendations for future research and conclusions will be made in Section 5.8.

5.1 Food waste produced at a retail level in New Zealand

Overall, fresh vegetables (including trimmings) were the largest contributor to discarded product, amounting to 27% of all food wasted or diverted at a retail level in New Zealand. Fresh fruit and fresh vegetables combined contributed to 44% of total wasted and diverted product. Tesco found that 35% of total food waste in UK stores was produce, and 39% in Central European stores (38, 43). These estimates are slightly less than estimates in the present study, however food donated to food rescue is not included in Tesco estimates which may contribute to this small difference. Lebersorger and Schneider found that 68% of total food waste and diversion measured in onsite audits was attributable to fresh fruit

and vegetables in Austrian supermarkets (33). Lebersorger and Schneider found that 89% of the fruit and vegetables wasted were discarded due to apparent imperfections (33). Perhaps Austrian retailers have higher quality expectations for produce which explains the greater proportion of produce waste observed. In the present study bakery goods contributed to 23% of total food waste and diverted product. This is similar to estimates for the proportion of bread waste reported by Brancoli in Sweden (30%) (35), Tesco in Central Europe (25%) (43), and Tesco in Ireland (22%) (42). However, Tesco estimates exclude donated food. Lebersorger and Schneider found that bread and pastry made up just 7% of total food waste in Austria (33), and only 8% of wasted food was bread in Tesco stores in the UK (38). Lebersorger and Schneider stated that the expense associated with wasted bread is significant, and is a driver for retailers to alter production schedules to minimise waste. (33) This awareness for minimising bakery waste could have contributed to the significantly smaller proportions of bread waste observed. The reasons for the low reported quantities of wasted bread by Tesco stores in the UK is unknown. In the present study dairy contributed to 6% of total food waste and diversion in New Zealand stores. Tesco reported that 8% of total food waste was dairy in UK (38) and Central European stores (43), and Lebersorger and Schneider reported that dairy was 6% of total food waste in Austrian stores (33), which is similar to the proportion estimate in the present study. Although Tesco estimates exclude donated food, dairy was not a popular food category for food donation in the present study. It can be assumed that dairy waste in New Zealand is similar to international estimates.

In total, it was estimated that approximately 23% of total food waste and diverted product is directed to landfill in the New Zealand retail sector, which is slightly less than the 28% estimated by the Food Waste Reduction Alliance to have been sent to landfill in 2016 by retailers in the US (45). As landfill is at the bottom of the food waste hierarchy, and the

least favourable destination for food waste, it is crucial to gain an understanding of what products are being sent to landfill and how waste to this destination can be reduced (21). Dairy is the food category that made the biggest contribution (i.e. 23%) to food waste directed to landfill. Many supermarkets struggle with diverting dairy due to its temperature sensitivity (32). Dairy reprocessing (i.e. the collection of dairy waste for reformulation) is an alternative destination for dairy waste in New Zealand, however this avenue was only utilised in one store audited. Managing dairy waste in-store should be a key waste management priority for retailers in New Zealand.

Bakery, and meat and fish each contributed to 21% of the total waste sent to landfill. As all meat and fish directed to protein reprocessing is trimmings (i.e. bone, fat and skin removed before sale), the majority of the meat and fish sent to landfill is actual product. Producing meat and fish is very resource intensive (i.e. 1kg of beef consumes 14 - 32 kg CO_2-e) (70), thus sending this to landfill is an inefficient use of resources. Food rescue organisations in New Zealand are beginning to accept meat that has been frozen before its use by date, an avenue that could be explored by more stores. One simple solution could be to ensure that all meat and fish product taken off the shelf as waste is placed in protein reprocessing bins. Although this would not act to reduce the quantity of waste produced, it would divert this product from landfill.

Advances in smart packaging could make a substantial impact on the waste of temperature sensitive foods such as dairy, meat, and fish (71). Improvements in packaging (i.e. active packaging which controls the environment inside the packet) could increase the shelf life of these products, and therefore the window of time within which the product must be sold (72). Some forms of smart packaging change colour depending on the freshness of the product by sensing changes in light or temperature inside the

packet (72). It is store policy in many supermarkets to discard food that has exceeded its best before date. Smart packaging could provide a more sensitive measure of deterioration specific to the individual food item, rather than a date label, which may help to keep safe food from being prematurely discarded (72). However, it is possible that foods in smart packaging may still be wasted but this would happen after a longer time on the supermarket shelf. Therefore, the introduction of smart packaging should be coupled with improvements to forecasting and ordering practices.

The overproduction of bakery goods is another key issue identified in this study. It is crucial that the amount of bakery waste is reduced, as this contributes to 23% of total food waste and diversion at a retail level. Attention needs to be paid to accurate forecasting and altering bakery production schedules based on sales. Issues with forecasting were also identified as a contributing factor to increased waste by Stenmarck et al (37). Research commissioned by WasteMINZ identified bread as the number one wasted food product by New Zealand households (10). Cicatiello et al. and Brancoli et al. also identified bread as a problematic food product in their case studies of Italian and Swedish retail food waste, respectively (31, 35). It is important to ensure that any waste reduction initiative at a retail level does not then push the waste down the supply chain to a household level (71). One of the major issues concerning the reduction of bakery waste is re-framing the cost-benefit analysis to retailers. One store manager stated that as bakery product is very cheap to produce, over production can be profitable because profit is still made when only one loaf out of 20 is sold.

5.1.1 The edibility of food waste and diversion product

Most studies analysing food waste separate food into edible and inedible product. In the present study, the candidate chose to present food waste as product and trimmings.

Product is the food available on the supermarket shelves. Trimmings is the 'inedible' waste removed from the food product prior to sale and not intended to be sold. Collaboration should be encouraged between retailers and entrepreneurs to create a new market for by-products (i.e. vegetable trimmings, bakery waste and dairy waste) generated at a retail level, and to establish mutually beneficial relationships between retailers and prospective businesses (71). Creating new food products out of by-products is becoming increasingly common, for example making crackers out of spent grain (73). Research could be conducted into ways that retailers can use commonly discarded food products to create new food products. Society needs to reframe ideas and social norms of what is edible, and view waste and trimmings as a product waiting to be harnessed rather than waste that cannot be avoided.

5.1.2 The waste of organic and premium food products

The candidate observed that a large proportion of organic or premium products were discarded, in particular dairy, bakery, and meat and fish products. Similar observations were made by Eriksson et al. in their study of the proportional wastage of organic products compared to their conventional alternatives (74). In Sweden, supermarkets are required to carry a selection of organic products and as the number or organic products on the market has increased, so too has the range of products required to be stocked (74). Mena et al. also commented on an increased demand for premium products including preservative-free foods in Spain and the UK (36). Upon comparing data collected by Eriksson from 2010 to 2011, the researchers observed that the weight of organic products sold decreased and the percentage of waste of organic products increased over the period monitored (74). Consumers of organic items often purchase these products as they

are perceived to be more environmentally friendly. However, if these products are being discarded at a higher rate than conventional products, this undermines the philosophy behind such products (74). Some possible explanations for the higher proportion of organic products wasted are the shorter shelf life of organic products and the lower turn-over of these products compared to their conventional counterparts (74). Retailers may need to adjust the quantities of each organic range they order, especially with increases in the range of products now available (74).

5.2 The importance of the food waste hierarchy at a retail level

According to their hierarchy, WRAP classify food that is donated to people or goes to animal feed as prevention rather than waste, as the food is still fed to people, or fed to animals which are eventually fed to people (21). However, WRAP highlight the importance of moving retail food waste further up the food waste hierarchy, with the main focus being reduction of waste at the source and the prevention of food going to landfill (18).

5.2.1 Diversion away from landfill

Results from this study indicate that an estimated 77% of all discarded food in the NZ retail sector is diverted away from landfill, this is slightly more than the 72% in the US retail sector by the Food Waste Reduction Alliance in 2016 (45). This suggests that retailers in New Zealand are dedicated to managing their waste and have invested time establishing avenues to divert waste from landfill. Filimonau and Gherbin had also identified through interviews with retail staff in the UK that food recycling and donation are a priority for retailers (50).

In this study, although some stores are still reliant on landfill collection as their main source of waste management, some stores are managing to divert the majority of their waste, with one store sending as little as 7kg of food to landfill per day (Supplementary Table 2 in Appendix 9). Tesco retail chain in the UK has consistently sent zero waste to landfill in the UK since 2009 (75). This achievement by Tesco is the result of a strong focus on food waste reduction in the UK for at least a decade (75), and been made possible by the plethora of landfill diversion avenues available such as anaerobic digestion (18). Anaerobic digestion is a common method of food waste disposal in the UK which is not well utilised in New Zealand, due to the large capital required to set up sorting, unpacking and processing facilities (18).

The Courtauld Commitment in the UK also plays a major role in encouraging retailers to be accountable for their food waste (39). In total, 85% of retailers in the UK have signed the Commitment for a 20% cut in all food and drink waste by the year 2025 (39). It is also stated in the Courtauld Commitment that by making progress toward achieving this target, groups are simultaneously working towards the publicly stated Sustainable Development Target 12.3, to halve all per capita food waste at retail and consumer levels by 2030 (7, 39). Retailers in New Zealand are following suit with the recent announcement by Countdown towards sending zero waste to landfill by 2020 (61). As this research shows, although New Zealand retailers are already managing to divert a large proportion of waste from landfill, there is still room for improvement with 14,000 tonnes of food estimated to be directed to landfill per year for all Countdown, New World and PAK'N'SAVE stores. All food destined for landfill could go to alternate destinations.

5.2.2 Diversion to animal feed

In this study, nearly half of all food not sold or used at a retail level was diverted as animal feed. Diverting food waste to feed livestock is a popular way of managing waste in New Zealand, and better than sending food to landfill. In the UK and countries throughout Europe, diverting food waste to animal feed is not as common (76). Concerns for donating waste to feed animals still exists in the UK due to the risk of diseases such as African Swine Fever and Foot and Mouth after the 2001 epidemic (76). In most countries across the UK and European Union donation of waste to feed animals is illegal, unless the waste has been certified as safe (i.e. no risk of contamination with animal product) or temperature treated (76). Based on WRAP's figures ~0.5kg/capita/year of food waste is diverted to feeding animals in the UK (18), in contrast to the estimated 6kg/capita/year in the New Zealand retail sector. In the UK, 80% of food diverted to animal feed is either bakery, fruit, or vegetable product (18), while those food categories make up 99% of New Zealand food waste diverted to animal feed.

5.2.3 Food donation

In New Zealand, it is estimated that approximately 15% of all food not sold or used at a retail level is donated to charities for human consumption. This is more than double that of the 7% of food donated by retailers in Austria reported by Lebersorger and Schneider (33). The smaller proportion of donated food observed in Austria could be attributable to store policy, where some retailers do not allow donation of food to charities (33). It was observed by the candidate that much of the food diverted to animal feed was of sufficient quality to be diverted to charities for people to consume. Most NZ supermarkets use the "Would I eat it?" criteria, where the staff member directs food to donation that they would eat themselves and diverts anything else to other destinations. Gruber et al.

highlight that understanding food waste is very subjective, and that 'the meaning of waste lies in the beholder' (48). Without clear communication around how staff should interpret food as waste or as edible product, unnecessary waste will occur. WRAP estimated that 17,000 tonnes of food currently donated for animal feed are suitable for human consumption in the UK, and that a further 93,000 tonnes of food that are wasted per year in the UK could be donated to food rescue organisations (18). Better guidelines for handling product and deciding upon its fate are needed at a retail level.

A significant factor preventing more food from being donated is the capacity of food rescue organisations to handle, store, and redistribute food. This issue was also highlighted as a significant barrier in New Zealand to further food waste reduction in semi-structured interviews. Without expansion of the food rescue sector, it is not feasible to divert all edible food not sold in supermarkets to humans (77). In the retail sector in Austria, it was found that bread was available for donation at a rate that exceeded the demand of the food rescue sector (77). Similar observations were made in the present study where certain supermarkets did not donate bakery items as the food rescue organisations could not handle the amount donated. At a retail level focus needs to shift to reducing food waste at the source. If the physical quantity of surplus food can be reduced, then the demand for food diversion avenues will not be as great, which would alleviate some of the pressure food rescue charities are currently under in terms of handling the quantities of food available to them (77).

Often it is difficult for food rescue charities to meet the financial demands of rent, operation, transport, delivery, and personnel (77). Most of the personnel work on a voluntary basis, and without the donation of hours and money, the food rescue industry could not sustain itself (77). SoWie, a food rescue charity in Austria, run a social

supermarket and a social coffee shop where a small fee is charged for the donated food (77). This is one way that the food rescue sector has attempted to generate money to cover some of its operational costs.

5.3 Components included in the definition of food waste

In this study, estimates for food waste are presented in a way that agrees with the FUSIONS definition, by presenting 'food waste' separately from food directed to animal feed and food donation (i.e. food diversion) (1). This was done in order to produce globally comparable estimates for New Zealand's retail sector. However, data is also presented as an aggregated total for food waste and diverted material to gain insight into all food at a retail level that is not sold or utilised. The candidate suggests the definition for retail food waste should encompass all food that is not sold, edible or inedible, with the primary focus being food waste reduction. It is more meaningful to analyse all food not sold or utilised at a retail level, and to regard all of this as food waste, rather than disregarding food destined for animal feed and food donation because it remains within the food supply chain. This would provide a clearer picture of what food is not being sold and therefore areas to target for waste reduction interventions. From a business point of view, any waste, no matter the destination, is a loss of profit and an inefficient use of resources for the retailer.

5.4 Comparisons to international estimates for retail food waste

Estimates for food waste in the New Zealand retail sector show that approximately 23,000 tonnes (i.e. 5kg/capita/year) of food waste, excluding food donated to humans or as animal feed, are generated per annum. This estimate excludes donated and diverted food in agreement with the FUSIONS definition (11). In contrast, estimates generated by

FUSIONS for retail food waste in Europe equate to approximately 9kg/capita/year, and vary greatly between countries, with some producing 4kg/capita/year, and others producing 30kg/capita/year (28). Overall, the New Zealand retail sector appears to be performing well in terms of managing retail food waste, producing almost half the per capita food waste of estimates recorded for Europe. The large range in values in the EU is likely attributable to different methods of quantification. Much of the data for retail food waste in the EU is self-reported by retailers and methods used by retailers are likely to vary. This variability justifies the need for standardised quantification protocols such as the FUSIONS manual and the Food Loss and Waste Accounting and Reporting standard (22, 41).

5.5 Comparisons to estimates for household food waste in New Zealand

Data collected by WasteMINZ only included household food waste destined for landfill in New Zealand (10), thus comparisons to this study can only be made with retail food waste destined for landfill. The methods used to extrapolate household food waste data to a national level were the same as the methods were used to scale retail estimates in this study. Estimates for food waste directed to landfill for New Zealand's retail sector are approximately 3kg/capita/year, compared to 29kg/capita/year at a household level (10). This shows that household food waste is 10-fold more per capita than retail food waste, which is unsurprising considering the streamlined waste management procedures at a retail level (32). The results of this study are important, as they suggest that households need to take a greater responsibility and better manage their food waste**.**

Retailers can play a role in helping consumers to reduce food waste. For example, by providing storage advice and recipes for utilising as much of the food products purchased as possible, and by influencing social norms and shopping behaviours (2, 71). Retailers in

the UK collaborated with the Love Food Hate Waste consumer waste reduction campaign to provide customers with storage options to increase the shelf life of their products (i.e. reusable salad bags, zip lock cheese bags, and vacuum packs for meat and poultry) (2). Champions 12.3, a group dedicated to achieving Sustainable Development Goal Target 12.3, conducted interviews with retail store managers which highlighted that customers believe retailers play a role in helping them to save money by reducing their food waste (2). The research also found that retailers responded to that need by actively informing customers of ways to reduce their household food waste (2). Furthermore, financial benefits were realised by retailers from products with longer shelf-life, commonly extended by sophisticated packaging, and this resulted in less food waste in-store and had flow on effects of reducing household food waste (2). It is clear that retailers play a crucial role in deciding what products and variety are available for consumers to purchase. Retailers can also use their position to nudge the consumer in the direction of purchasing food in a less wasteful manner, and this is likely to have positive repercussions for their business (2). Not only will supporting the consumer to make good decisions help to gain their loyalty, but will also help the consumer to save money by wasting less food, and thus free up more disposable income to spend on higher quality products in-store with more substantial profit margins (2, 71).

5.6 Motivators and barriers to further retail food waste reduction

Food waste reduction interventions are unlikely to be successful unless they address both the motivators and barriers to reducing food waste (52). The qualitative component of this study was designed to uncover some of the key motivators and barriers for further food waste reduction at a retail level.

5.6.1 Understanding the motivators that drive retail food waste reduction

In the present study, environmental protection was a dominant motivator for food waste reduction in a retail setting. The 'clean, green' image of New Zealand may be at the forefront of many of the interviewee's minds, which may cause retailers to be more aware of the environmental impacts of their actions and their personal responsibility to protect the environment. This differs from interviews by Gruber et al. (study location not disclosed) (48), and Hocke in the Netherlands (51), as environmental motivators were not articulated by retail managers in either study. However, interviews with business leaders throughout the entire food supply chain (including retail), and across three continents, conducted by Champions 12.3, identified that environmental sustainability was a driver for food waste reduction (2).

The present study also identified financial motivators as important drivers for food waste reduction. From a business perspective, reducing food waste will reduce loss of profit from wasted product, as well as costs associated with waste disposal. In a study about retail food waste in the Netherlands, Hocke found profitability to be an important motivator for food waste reduction (51). A cost-benefit analysis conducted by Champions 12.3 showed that for every $1 invested by retailers in food waste reduction, an average of $5.1 of realised benefit would be gained (2). Financially incentivising food waste reduction could be a strategic approach to motivate more retailers to reduce their waste. It would be advantageous to develop a cost benefit analysis for the reduction of food waste specifically catered to New Zealand retailers, to quantify the associated upfront costs against the long-term financial benefit including meeting reduction targets and the subsequent savings.

In addition to environmental and financial motivators, other non-financial motivators are also important to retailers for food waste reduction (2). Non-financial barriers such as satisfying ethical responsibility and strengthening customer relationships were noted as significant motivators for retailers to reduce food waste by Champions 12.3 (2). Drivers for food waste reduction related to food security were also articulated by business leaders across the food supply chain interviewed by Champions 12.3 (2). This sense of ethical responsibility and concerns for food security can be translated into the theme identified in the present study as caring for the community. Interviewees in the present study commented that there is a social responsibility for retailers to do the 'right' thing and reduce food waste. This links in with strengthening customer relationships mentioned above by showing customers that the business is dedicated to doing the 'right' thing by managing their waste sustainably (2). The benefits, including reputation and gaining customer loyalty through taking social responsibility to manage in-store waste and support the community by donating food, should not be underestimated (71).

5.6.2 Understanding the barriers preventing further retail food waste reduction

The most important barrier to the reduction of retail food waste was training and education, which was articulated 30 times throughout the data set. Clear and easy to follow systems and empowering staff to make the right decisions are crucial for the success of waste reduction initiatives, and this requires increased staff training. However, a difficulty with staff training noted by Gruber et al. is that many retail staff work part-time on low wages, therefore there is a high turnover of staff (48). Given this problem, the cost of throwing away food may be less than the cost of training staff on waste management procedures (48). This is a significant challenge for the sector. However, investment in training staff in the present is likely to result financial and non-financial

benefits for retailers in the future (2). Gruber et al. suggested that an in-store reward based system could be an effective way of motivating staff to follow waste management procedures. For example, good performance could be rewarded in 'bonus hours' when targets are met in order to obtain buy-in from staff members (48).

Food safety regulations were also a dominant theme articulated as a barrier in the present study. Retailers mentioned that often perfectly edible product had to be discarded due to the retail company's regulation around date labelling. The 'immunity for food donors' clause was introduced in New Zealand in the Food Act 2014 and aimed to protect a food donor from liability if the product was deemed fit for purpose at the time of donation (78). Despite this clause, retailers continue to act with caution when donating food. Gruber et al. noted that the regulatory environment at a store level was associated with the generation of increased quantities of food waste (48). The legal requirement of presenting a best before date is one example of how a source of edible food can be removed from shelves. Caution about food safety is difficult for retailers who have stated that regulations are "imposed upon us by society and producers as well" (48).

Issues concerning best before date labelling and their contribution to the generation of food waste were also raised by Eriksson, Lebersorger and Schneider, and Mena et al. (32, 33, 36). Eriksson stated that the guaranteed time of maintained quality of a product (i.e. the best before date) is typically between half and two thirds of the shelf-life (74). Lebersorger and Schneider commented in their study of food waste in Austria, that the best before date had not been exceeded for one-third of products discarded; none presented a use by date (33). There is not only a regulatory issue with products being required to be removed from the shelf after the best before date has been reached, but also the push-back effect by consumers (36). Consumers do not want to purchase product that

is close to the date shown on the label, they demand fresh products, and often choose products that have a longer-shelf life (36). However, with advances in smart packaging with more precise indicators of product safety and freshness, date labelling may become obsolete in the future (71).

The desire by both retailers and consumers for high quality products was another barrier to waste reduction identified in the present study. This barrier was also noted by Gruber et al. and Stenmarck et al. during interviews with store managers (37, 48). Stores overstock shelves in order to make displays full and appealing to customers. Stenmarck et al. identified that some retailers over-cater by more than 7% to ensure that customers' needs are met (37). In the present study, many stores commented that poorer quality product was removed from shelves to ensure that customers are satisfied with the standard of product in-store and to keep their loyalty.

Diversion avenues and capacity was also a barrier, for example in this study not all stores had access to pig farmers or food donation facilities, or these diversion routes couldn't cope with the amount of wasted product. It is crucial to encourage retailers to reduce the physical quantity of waste. The flow on effect of this will lead to a decreased demand for diversion avenues. It was also mentioned by several retailers that they are unsure what diversion avenues are available to them, and believe that some food products cannot be diverted, despite this being possible. Mena et al. echo the notion that many retailers are ill-informed about the possible diversion avenues for food waste that exist, and suggest that attention needs to be drawn to avenues available for diverting food waste, and resources need to be invested into these alternate avenues to ensure that waste diversion can take place (36).

The storage space required to keep food aside for recipients and time needed for staff to separate food from waste, or carry out additional processes, are costs to the business. Having the available resources (i.e. time and space) was recognised as a significant barrier to reducing waste by key retail staff in the present study. Lebersorger and Schneider, and Hocke also identified that the storage space and time required to donate food are substantial costs to the business, however, from a waste management perspective the investment of these resources is beneficial (33, 51). One retailer in the Netherlands interviewed by Hocke suggested that being presented with information about the cost of additional waste management procedures in terms of materials and time, and the subsequent savings would encourage retailers to invest the necessary resources into managing their waste (51).

It is possible to overcome all of these barriers, although a cross-sectoral approach may be required. Working with consumers to reduce retail food waste will be crucial moving forward. It is clear from the qualitative baseline data in this study that retailers are invested in food waste reduction, as effectively managing food waste is strongly linked with both profit and moral obligations for the sector.

5.7 Strengths, limitations and challenges

5.7.1 Strengths

The study was the first of its kind to quantify food waste at a retail level in a New Zealand setting. A major strength of this study was gaining approval from both retail chains to conduct onsite audits of food waste. The time spent on communication with the retail bodies played a significant role in allowing the research team to collect quantitative data. In total 16 onsite audits were conducted, across four locations, which is more than any other retail food waste quantification study identified that conducted onsite food

waste audits (18, 32, 33). Directly weighing food waste in onsite audits is the most precise way of collecting data on the quantity of retail food waste. Both standard definitions for food waste and standard protocol for food waste quantification were used in the present study (11, 22, 41). To the best of the research team's knowledge, this study was the first to use the Food Loss and Waste Accounting Reporting Standard guidelines to quantify retail food waste in the Asia-Pacific region. The use of these best-practice protocols allowed for the generation of internationally comparable estimates for retail food waste.

Using a mixed methods approach to researching retail food waste in New Zealand allowed progress to be made towards both the 'measure' step and 'act' steps of the Sustainable Development Goal Target 12.3. The quantitative arm of the study provided insights into the quantity, composition, and current management of retail food waste in New Zealand. The qualitative arm of the study provided insights into the most effective ways to design and frame future waste reduction interventions, that will resonate with retail staff who carry out the waste management procedures.

Collaborating with industry to define the scope allowed the research team to design a study that could provide useful data to retailers, with the aim of bringing about change. A major contribution of this research is not only to provide publicly available data on retail food waste in New Zealand, but to provide information to retailers about areas to focus attention on. The retail industry can use this quantitative data as a road map for reducing food waste in targeted and effective ways, and as a benchmark to monitor their progress against.

5.7.2 Limitations and challenges

There were, however, limitations to the present study and it is important to acknowledge these. Retailers were asked to select stores to participate in the study. A self-selected sample can introduce bias due to retailers choosing to recruit stores that are more likely to have better waste management practices (74), which could lead to an underestimation of food waste at a retail level. The reason for obtaining a convenience sample was to ensure that the stores who were recruited would be willing to participate and compliant with the requirements of the study within the short timeframe available. Convenience sampling is a common method of recruitment in food waste quantification studies (32, 34, 36). The research team aimed to reduce this potential bias by stressing to retailers that both well performing stores and poorer performing stores were being recruited in order to provide the retail bodies with accurate data on their food waste behaviours. From observing the data collected in stores within each retail chain, it appeared that each chain did provide a range of stores.

While undertaking audits, informal observations were made and noted by the candidate, supervisors and volunteers. However, there were no specific or formal criteria for measuring and recording observations (i.e. a large proportion of organic product was wasted, and a large proportion of fruit and vegetables donated as animal feed could have gone to humans). It is important to acknowledge that the observations presented in the results section of this thesis are subjective, and this is a limitation of the study.

As the stores included were not representative of all Countdown, New World and PAK'n'SAVE stores in New Zealand, caution must be used when interpreting data scaled to obtain a national estimate. Supermarkets located rurally are likely to have different waste patterns compared to urban supermarkets, due to a greater range and number of

available waste diversion options in urban centres. Therefore, it is likely that the present study has over-estimated the amount of food diverted to food donation and under-estimated the amount of food sent to landfill at a national level.

Another potential limitation is the exclusion of stores that process their protein off-site from the final analysis. It is likely that protein waste has been overestimated in the sample presented here. In the future, it could be useful to include a representative number of stores with onsite and offsite protein processing.

Due to time and budget constraints of the present study all qualitative interviews were transcribed by the candidate. Although consistency was achieved by having one person conduct the process, a limitation was that quality assurance checks were not carried out by a third party.

A limitation in most food waste quantification studies is the failure to account for the density of food products (74). Food waste is most commonly measured in units of mass (i.e. kilograms or tonnes), however the density of these products is not accounted for. For example, fruit and vegetables have a high water content and are heavier per cm^3 than bread, which is very light (74). Eriksson also made this observation, and suggested that comparisons can be made using monetary value or measures of environmental impact. However, no matter which way the author choses to present results, there are limitations (74). For example, the monetary value of a product changes as it passes through the food supply chain making cross-sectoral comparisons difficult (74). One possible solution could be to devise a set of conversion factors that account for the density of a food product.

5.8 Recommendations and conclusions

5.8.1 Recommendations for future research

Now that initial quantification of food waste has been undertaken for the retail sector, future studies can compare their results to the baseline data provided in this study.

Recommendations for future research:

- With more time and a larger budget it might be possible to recruit a randomly selected, generalisable sample of supermarkets in New Zealand. It would be beneficial to re-audit each store 6 months after the first audit in order to account for seasonal variation. It would be advantageous to monitor a subset of stores over the course of one year, as recommended by the Food Loss and Waste Accounting and Reporting Standard, in order to gain insight into changes in waste patterns overtime. It would also be beneficial to develop formal criteria for recording and measuring observations made in store to enable a better understanding of the reasons that food waste occurs.

- The qualitative results from this research could be used to design an intervention that appeals to the motivators identified in the present study (i.e. environmental protection and increased profit) and overcomes the barriers (i.e. staff training). A randomised controlled trial could be undertaken to monitor the effectiveness of waste reduction interventions developed and the results could then be compared to the quantitative baseline data generated from the present study.

- Conducting a cost-benefit analysis into viable food waste reduction initiatives for the retail sector would be extremely valuable. It is important to present retailers with information on the resources required for implementation and the potential social, environmental, and economic benefits of introducing new processes.

Retailers are far more likely to respond well to interventions if the benefits clearly outweigh the costs and effort involved.

5.8.2 Recommendations for retailers

From the results of this research, a series of recommendations have been developed to assist New Zealand retailers with food waste minimisation.

Recommendations for retailers:

- Focus needs to be placed on what food can be diverted from landfill to other waste management avenues, particularly for dairy and meat and fish.
- Changes need to be made to production schedules to decrease the quantity of bread produced. The food rescue market is already saturated with bakery product, therefore reduction is crucial.
- Retailers should continue to support local farmers and food rescue organisations by donating food, however food waste reduction should always remain the priority, as any waste is a cost to the business.
- Retailers should develop resources and consumer-facing campaigns in-store to encourage customers to reduce their food waste, and make sensible purchasing and storage decisions. Aiding consumers in reducing their food waste has been associated with benefits for retailers (i.e. gaining customer loyalty through providing additional support, helping to free-up some disposable income that customers may spend on high quality items with larger profit margins).
- Retailers should investigate opportunities to collaborate with businesses that can use retail food waste to create new food products. These opportunities could be mutually beneficial.

- An in-store training programme targeted at waste management should be developed in order to overcome the barrier to waste reduction of training and education. This programme should include information about the social, environmental, and financial benefits associated with better waste management procedures to appeal to the motivators identified during interviews.

5.8.3 Conclusions

In summary, New Zealand retailers appear to be making a significant effort to reduce the waste they send to landfill. Of products sent to landfill, dairy, meat and fish, and bakery are the largest contributors. Almost 50% of all food measured was directed to animal feed, with a substantial amount suitable for human consumption. The food waste hierarchy prioritises the reduction of the quantity of food waste, followed by redistribution, recycling and then disposal (21). At a retail level, the focus should be on reducing the physical quantity of food waste produced at the source. The present study questions the relevance of the FUSIONS definition of food waste for the retail sector (11), and suggests that all food not sold at a retail level should be considered as food waste. It is important that any intervention makes the most effective use of resources. Framing an intervention in a way that motivates retail staff and overcomes barriers is essential to reduce food waste in an informed and purposeful way.

.

Bibliography

1. Gustavsson J, Cederberg C, Sonesson U, Van Otterdijk R, Meybeck A. Global food losses and food waste. Rome: Food and Agriculture Organization of the United Nations, 2011.
2. Hanson C, Mitchell P. The Business Case for reducing Food Loss and Waste.Washington, DC: Champions 12.3, 2017.
3. Food and Agriculture Organization. Food Wastage Footprint & Climate Change. Rome: UN FAO, 2015.
4. United Nations. Sustainable Development Knowledge Platform. Version current 2017. Internet: https://sustainabledevelopment.un.org/ (accessed 12 October 2017).
5. New Zealand Ministry of Foregin Affairs and Trade. Sustainable Development Goals. Version current 2017. Internet: https://www.mfat.govt.nz/en/peace-rights-and-security/work-with-the-un-and-other-partners/new-zealand-and-the-sustainable-development-goals-sdgs/ (accessed 12 October 2017).
6. United Nations. Sustainable Development Goal 12: Ensure Sustainable Consumption and Production Patterns. Version current 2017. Internet: https://sustainabledevelopment.un.org/sdg12 (accessed 12 October 2017).
7. Lipinski B, Clowes A, Goodwin L, Hanson C, Swannell R, Mitchell P. SDG Target 12.3 on Food Loss and Waste: 2017 Progress Report. Washington, DC: Champions 12.3, 2017.
8. Lipinski B, Hanson C, Lomax J, Kitinoja L, Waite R, Searchinger T. Reducing Food Loss and Waste. Washington, DC: Waste and Resources Institute, 2013.
9. Parfitt J, Barthel M, MacNaughton S. Food waste within food supply chains: quantification and potential for change to 2050. Philos. Trans. Royal Soc. B. 2010;365:3065-81.
10. Yates S. New Zealand Food Waste Audits. Auckland, New Zealand: WasteMINZ, 2015.
11. European Union FUSIONS. FUSIONS Definitional Framework for Food Waste. Version current 2016. Internet:https://www.eufusions.org/phocadownload/Publications/FUSIONS%20Definitional%20Framework%20for%20Food%20Wate%202014.pdf (accessed 2 April 2017).

12. Reisinger H, Acoleyen M, O'Connor C, et al. Evolution of (bio-) waste generation/prevention and (bio-) waste prevention indicators. Paris: European Commission, 2011.
13. Waste and Resources Action Programme. Household Food and Drink Waste in the UK. Banbury:Waste and Resources Action Programme, 2009.
14. Valley proteins. Turnkey supermarkets meat and grease waste recycling services. Version current 2017. Internet: http://www.valleyproteins.com/rendering-services/supermarkets/ (accessed 17 October 2017).
15. Food and Agricultural Organization. Food loss prevention in perishable crops. [FAO agricultural service bulletin no 43]. Rome: UN FAO, 1981.
16. Bloom J. American wasteland: How America throws away nearly half of its food (and what we can do about it). Boston, MS: Da Capo Press, 2010.
17. Beretta C, Stoessel F, Baier U, Hellweg S. Quantifying food losses and the potential for reduction in Switzerland. Waste Manag. 2013;33:764-73.
18. Parfitt J, Woodham S, Swan E, Castella T, Parry A. Quantification of food surplus, waste and related materials in the grocery food supply chain. Banbury: Waste and Resources Action Programme, 2016.
19. Smil V. Improving Efficiency and Reducing Waste in Our Food System. J Environ Sci. 2004;1:17-26.
20. Stuart T. Waste: Uncovering the global food scandal. London: Penguin books, 2009.
21. Whitehead P, Parfitt J, Bojczuk K, James K. Estimates of waste in the food and drink supply chain. Banbury: Waste and Resources Action Programme, 2013.
22. Tostivint C ÖK, Quested T, Soethoudt H, Stenmarck Å, Svanes E, O'Connor C. Food waste quantification manual to monitor food waste amounts and progression. Paris: FUSIONS, 2016.
23. European Parliament Council. A Community Strategy for Waste Management. Brussels: EU Commission, 1989.
24. Papargyropoulou E, Lozano R, Steinberger JK, Wright N, Ujang ZB. The food waste hierarchy as a framework for the management of food surplus and food waste. J Cleaner Prod. 2014;76:106-15.
25. The U.S. Environmental Protection Agency. A guide to conducting and analyzing a food waste assessment. Version current 2017. Internet: https://www.epa.gov/

sites/production/files/2015-08/documents/r5_fd_wste_guidebk_020615.pdf (accessed 4 September 2016).

26. Kummu M. de Moel H, Porkka M, Siebert S, Varis O, Ward PJ. Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. Sci Total Environ. 2012;438:477-89.
27. Buzby JC, Hyman J. Total and per capita value of food loss in the United States. Food Policy. 2012;37:561-70.
28. Stenmarck Å, Jensen C, Quested T, Moates G. Estimates of European food waste levels. Stockholm: FUSIONS, 2016.
29. Cicatiello C, Franco S, Pancino B, Blasi E, Falasconi L. The dark side of retail food waste: Evidences from in-store data. Resour Conserv and Recy. 2017;125:273-81.
30. Hall KD, Guo J, Dore M, Chow CC. The progressive increase of food waste in America and its environmental impact. PLoS One. 2009;4:e7940.
31. Cicatiello C, Franco S, Pancino B, Blasi E. The value of food waste: An exploratory study on retailing. J Ret Con Ser. 2016;30:96-104.
32. Eriksson M. Retail Food Wastage: A case study approach to quantities and causes department of energy and technology. Department of Energy and Technology: Swedish Univerity of Agricultural Sciences, 2012.
33. Lebersorger S, Schneider F. Food loss rates at the food retail, influencing factors and reasons as a basis for waste prevention measures. Waste Manag. 2014;34:1911-9.
34. Buzby J, Bentley J, Padera B, Ammon C, Campuzano J. Estimated Fresh Produce Shrink and Food Loss in U.S. Supermarkets. Agriculture. 2015;5:626-48.
35. Brancoli P, Rousta K, Bolton K. Life cycle assessment of supermarket food waste. Resour Conserv Recyc. 2017;118:39-46.
36. Mena C, Adenso-Diaz B, Yurt O. The causes of food waste in the supplier–retailer interface: Evidences from the UK and Spain. Resour Conserv Recyc. 2011;55:648-58.
37. Stenmarck Å, Hanssen OJ, Silvennoinen K, Katajajuuri JM, Werge M. Initiatives on prevention of food waste in the retail and wholesale trades. Stockholm: Swedish Environmental Research Institute, 2011.

38. Tesco PLC. UK Food Waste Data. Version current 2017. Internet: https://www.tescoplc.com/little-helps-plan/products-food-waste/uk-food-waste-data/ (accessed 18 October 2017).
39. WRAP. The Courtauld commitment - what is it? Version current 2017. Internet: http://www.wrap.org.uk/content/what-is-courtauld (accessed 2 January 2017).
40. The British Retail Consortium. The retail industry's contribution to reducing food waste. Version current. Internet: https://brc.org.uk/media/105811/10105-brc-food-waste-report-final.pdf (accessed 3 November 2017).
41. Hanson C Lipinski B, Robertson K, et al. Food Loss and Waste Accounting and Reporting Standard. Version current 2017. Internet: https://www.wri.org/sites /default/files/REP_FLW_Standard.pdf (accessed 2 January 2017).
42. Tesco PLC. Tesco Ireland, food waste data. Version current 2017. Internet: http://www.tescoireland.ie/tesco-and-community/food-waste/food-waste-data (accessed 18 October 2017).
43. Tesco PLC. Central European Food Waste Data. Version current 2017. Internet: https://www.tescoplc.com/little-helps-plan/products-food-waste/central-european-food-waste-data/ (accessed 18 October 2017).
44. Tesco PLC. Tackling food waste in our own operations.Version current 2017. Internet: https://www.tescoplc.com/little-helps-plan/products-food-waste/our-own-operations/ (accessed 5 September 2017).
45. The food waste reduction alliance. Analysis of U.S. food waste among food manufacturers, retailers, and restaurants. Version current 2017. Internet: http://www.foodwastealliance.org/wp-content/uploads/2013/05/FWRA-Food-Waste-Survey-2016-Report_Final.pdf (accessed 12 August 2017).
46. The food waste reduction alliance. Analysis of U.S. food waste among manufacturers, retailers, and restaurants. Version current 2016. Internet: http://www.foodwastealliance.org/wp-content/uploads/2014/11/FWRA_BSR _Tier3_FINAL.pdf (accessed 12 August 2016).
47. European Commission. Preparatory Study on FoodWaste across EU27. Version current 2016. Internet: http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste _report.pdf (accessed 2 June 2016).
48. Gruber V, Holweg C, Teller C. What a Waste! Exploring the Human Reality of Food Waste from the Store Manager's Perspective. J Public Policy Mark. 2016;35:3-25.

49. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. Qual Health Res. 2005;15:1277-88.
50. Filimonau V, Gherbin A. An exploratory study of food waste management practices in the UK grocery retail sector. J Clean Prod. 2017;167:1184-94.
51. Hocke L. Encouraging food waste reduction - policy options for the Dutch context to encourage retail's efforts for food waste reduction in the supply chain. Faculty of Geoscience: University of Utrecht, 2014.
52. Graham-Rowe E, Jessop DC, Sparks P. Identifying motivations and barriers to minimising household food waste. Resour Conserv and Recy. 2014;84:15-23.
53. Ross J. Food waste in an airline caterer's production kitchen. Department of Human Nutrition: University of Otago, 2014.
54. Reynolds C, Mirosa M, Clothier B. New Zealand's Food Waste: Estimating the Tonnes, Value, Calories and Resources Wasted. Agriculture. 2016;6:9.
55. Goonan S, Mirosa M, Spence H. Getting a taste for food waste: a mixed methods ethnographic study into hospital food waste before patient consumption conducted at three New Zealand foodservice facilities. J Acad Nutr Diet. 2014;114:63-71.
56. Loh J. The possibilities of reducing food choice to improve the economical (profits), nutritional psychological (people) and environmental (planet) performance of university residential college foodservices. Department of Human Nutrition: University of Otago, 2014.
57. Mirosa M, Munro H, Mangan-Walker E, Pearson D. Reducing waste of food left on plates. British Food Journal. 2016;118:2326-43.
58. Niimi M. Design for sustainability: addressing food waste behaviour. Department of Design: University of Otago, 2012.
59. Parr H. Food waste New Zealand: A case study investigating the food waste phenomenon. Faculty of Design and Creative Technologies: Auckland University of Technology, 2013.
60. Stoddart A. A matter of waste: making experiences and perceptions of household waste visable. Department of Sociology, Gender, and Social Work: University of Otago, 2013.
61. Countdown. 2017 corporate responsibility report. Version current 2017. Internet: https://www.countdown.co.nz/media/8686/countdown-cr-report-nov-2017.pdf (accessed 30 November 2017).

62. Countdown press office. Countdown shows love for ugly fruit and veges. Version current 20 February 2017. Internet: https://www.countdown.co.nz/news-and-media-releases/2017/february/countdown-shows-the-love-to-ugly-fruit-and-veges (accessed 20 August 2017).
63. Sammons M, Bridgman S. Foodstuffs NZ - PAK'N'SAVE waste (and money) for a new world - a new collaborative business model for waste management and minimisation. Version current 2017. Internet: http://www.wasteminz.org.nz/wp-content/uploads/WasteMINZ-2014-FOODSTUFFS-NZ-%E2%80%93-PAK%E2%80%99N%E2%80%99SAVE-WASTE-AND-MONEY-FOR-A-NEW-WORLD.pdf (accessed 23 April 2017).
64. WasteMINZ. Foodstuffs' food waste. Version current March 2017. Internet: https://www.wasteminz.org.nz/wp-content/uploads/2017/03/e-Revolve-March-2017.pdf (accessed 20 May 2017).
65. Statistics New Zealand. 2013 Census map – QuickStats about a place. Version current 2017. Internet: http://archive.stats.govt.nz/StatsMaps/Home/People and households/2013-census-quickstats-about-a-place-map.aspx (accessed 21 January 2017).
66. Countdown. Our company. Version current 2017. Internet: https://www.countdown.co.nz/about-us/our-company (accessed 2 April 2017).
67. Foodstuffs. Our brands. Internet: https://www.foodstuffs.co.nz/our-brands (accessed 2 April 2017).
68. Reynolds C, Mirosa M. A load of rubbish: quantifying food waste in New Zealand. A confidential report prepared for WasteMINZ, 2013.
69. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3:77-101.
70. de Vries M, de Boer IJM. Comparing environmental impacts for livestock products: A review of life cycle assessments. Livest Sci. 2010;128:1-11.
71. Arias Bustos C. The role of food retailers and technology in reducing consumer food waste. Version current 2017. Internet: https://www.capgemini.com/wp-content/uploads/2017/10/food-waste-management_web.pdf (accessed 12 January 2017).
72. Mohebi E, Marquez L. Intelligent packaging in meat industry: An overview of existing solutions. J Food Sci Technol. 2015;52:3947-64.

73. Aliya S, Bala M. Brewer's spent grain: A review of its potentials and applications. Afr J Biotechnol. 2011;10:324-331.
74. Eriksson M, Strid I, Hansson P-A. Waste of organic and conventional meat and dairy products—A case study from Swedish retail. Resour Conserv Recy. 2014;83:44-52.
75. Tesco PLC. Waste and recycling in the UK. Version current 2017. Internet: https://www.tescoplc.com/little-helps-plan/reports-policies-and-disclosure/recycling-in-the-uk (accessed 5 September 2017).
76. Salemdeeb R, Ermgassen EK, Kim MH, Balmford A, Al-Tabbaa A. Environmental and health impacts of using food waste as animal feed: a comparative analysis of food waste management options. J Clean Prod. 2017;140:871-80.
77. Schneider F. The evolution of food donation with respect to waste prevention. Waste Manag. 2013;33:755-63.
78. The Parliament of New Zealand. Food Act 2014. Wellington, 2017.

Appendices

Appendix 1 – Ethical approval

D17/137

Academic Services
Manager, Academic Committees, Mr Gary Witte

5 May 2017

Assoc. Prof. S Skeaff
Department of Human Nutrition
Division of Sciences

Dear Assoc. Prof. Skeaff,

I am writing to confirm for you the status of your proposal entitled "**Retail Food Waste - a quantification exercise**", which was originally received on May 1, 2017. The Human Ethics Committee's reference number for this proposal is **D17/137**.

The above application was Category B and had therefore been considered within the Department or School. The outcome was subsequently reviewed by the University of Otago Human Ethics Committee. The outcome of that consideration was that the proposal was approved.

Approval is for up to three years from the date of HOD approval. If this project has not been completed within three years of this date, re-approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

Yours sincerely,

Mr Gary Witte
Manager, Academic Committees
Tel: 479 8256
Email: gary.witte@otago.ac.nz

Appendix 2 – Information sheet for participants

[Reference Number: *D17/137*]

[*5 May 2017*]

RETAIL FOOD WASTE – A QUANTIFICATION EXERCISE
INFORMATION SHEET FOR PARTICIPANTS

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you and we thank you for considering our request.

What is the Aim of the Project?

The purpose of this research is to gain an in-depth insight into the composition and quantity of retail food waste in New Zealand. The study involves onsite waste audits in selected supermarkets across New Zealand and interviews with key grocery personnel. This information sheet is for stores participating in onsite waste audits (Activity 1) and personnel (or key stakeholders) who are participating in an interview (Activity 2). This project is being undertaken as part of the requirements for Francesca Goodman-Smith's Master of Science.

What Types of Participants are being sought?

Store managers, waste managers and sustainability co-ordinators employed by major grocery retailers in New Zealand.

What will Participants be asked to do?

We are asking participants to undertake two activities: Activity 1 is an onsite waste audit and Activity 2 is an interview(s) with key grocery personnel. However, you are free to decide to take part in only one activity.

Activity 1 (onsite waste audits): Should you agree to take part in this project, managers of participating stores will be asked to organise an appropriate time for the research team to carry out the audit in store. You will be asked meet the research team upon arrival and direct them to the designated audit area (which will not disturb your staff). The audit will involve minimal staff participation and should not affect the normal flow of business.

The time commitment of the audit is approximately half a day. If at any time you feel that participating in the audit is posing an inconvenience to you and your staff, please make the research team aware, and you may choose to withdraw from the study. Please be aware that you may decide not to take part in the project without any disadvantage to yourself.

Activity 2 (interviews): Should you agree to take part in this project, key grocery personnel will be asked to answer a series of open-ended questions concerning attitudes towards retail food waste, positive changes which have happened in the space, scope for improvement and recommendations for future initiatives.

The time commitment of the interview is 15-20-minutes. If at any time you feel that participating in the interview is causing you discomfort or posing an inconvenience to you, please make the researcher aware, and you may choose to withdraw from the interview. Please be aware that you may decide not to take part in the project without any disadvantage to yourself.

What Data or Information will be collected and what use will be made of it?
Information collected during the audit will be used to generate estimates of overall retail food waste in New Zealand. In the reporting of the data no information concerning the store name or location will be used.

Interviews will involved an open-questioning technique. The general line of questioning includes attitudes towards retail food waste, positive changes which have happened in the space, scope for improvement and recommendations for future initiatives. The precise nature of the questions that will be asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the Department of Human Nutrition is aware of the general areas to be explored in the interview, the Human Ethics Committee has not been able to review the precise questions to be used. In the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable you are reminded of your right to decline to answer any particular question(s).

The interview will be audio recorded for the use of the research team only. Neither the audio recordings, nor anything you say during the course of the session will be available to anyone outside the current research group. After the interview the audio recording will be transcribed; the transcripts will not be available to anyone outside the research group. During transcription your name will be removed and replaced with a pseudonym so that your identity will not be disclosed in the reporting of the research.

Any personal information provided during the interview will only be used to assist in explaining the study results. Personal information will be published only as aggregate values (e.g. store managers interviewed). After collection, data will be transferred onto a USB memory-stick and stored in a filing cabinet in the Department of Human Nutrition at the University of Otago. The data will only be accessible to Francesca Goodman-Smith, Dr. Sheila Skeaff and Dr. Miranda Mirosa, as required by the University's research policy. Any raw data on which the results of the project depend will be retained in secure storage for five years, after which time they will be destroyed.

The results of the project may be published in which case they will be available in the University of Otago Library (Dunedin, New Zealand). Every attempt will be made to preserve your anonymity.

Can Participants Change their Mind and Withdraw from the Project?

You may withdraw from participation in the project at any time and without any disadvantage to yourself of any kind.

What if Participants have any Questions?

If you have any questions about our project, either now or in the future, please feel free to contact either:

Francesca Goodman-Smith
Department of Human Nutrition
Email: goofr582@student.otago.ac.nz

and/or

Dr. Sheila Skeaff
Department of Human Nutrition
Email: sheila.skeaff@otago.ac.nz
Telephone: 03 479 7944

This study has been approved by the Department stated above. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479-8256). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

Appendix 3 – Consent form for participants

RETAIL FOOD WASTE – A QUANTIFICATION EXERCISE

CONSENT FORM FOR

PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:-

1. My participation in the project is entirely voluntary;

2. I am free to withdraw from the project at any time without any disadvantage;

3. Personal identifying information e.g. audio-recordings and transcripts will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for at least five years;

4. Interviews involves an open-questioning technique. The general line of questioning includes attitudes towards retail food waste, positive changed which has happened in the space, scope for improvement and recommendations for future initiatives. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops and that in the event that the line of questioning develops in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s) and/or may withdraw from the project without any disadvantage of any kind.

5. If you feel uncomfortable at any point during the interview or inconvenienced during the audit, you may withdraw at any point without any disadvantage;

6. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve my anonymity.

I, as the participant: a) agree for my store to take part in the onsite audit, ☐

Store Name:……

☐

b) agree for selected personnel take part in the interview

I agree to take part in this project.

....
(Signature of participant) (Date)

.....
(Printed Name)

Appendix 4 – Food categories classified by WasteMINZ (10)

1. BAKERY
Bagels
Bread roll/baguette
Mixed grain bread
Wheatmeal bread
White bread
Breadsticks
Brioche
Cake
Croissants
Crumpets
Danish pastries
Dough
Doughnuts
Dumplings
Fruit loaf and fruit buns
Garlic bread
Hot cross buns
Muffin
Other bakery
Pastry
Pies
Potato cakes
Scones
Waffles

2. MEAT AND FISH
Beef
Bacon
Burgers
Corned beef
Cured meat
Fish canned
Fish fingers
Fresh fish
Ham
Hotdogs/frankfurters
Lamb liver
Lamb/mutton
Meatballs
Mincemeat
Mussels, live
Mussels, marinated
Other meat & fish
Oysters
Pork
Sandwich spreads
Sausages
Unidentifiable/mixed bones
Unidentified meat/offal

3. DAIRY
Cheese
Cream
Crème fraîche
Cottage cheese
Eggs
Milk
Milk flavoured
Other dairy
Sour cream
Soya milk
Yoghurt/yoghurt drinks

4. STAPLE FOOD
Bran flake cereal
Cornflakes
Dried fruit
Flour
Museli
Oats
Other breakfast cereals
Other dried foods
Pasta
Powdered soups and drinks
Rice
Wheat biscuit cereals

5. FRESH FRUIT
Apples
Apricot
Avocados
Bananas
Berries
Cherries
Feijoa
Grapes
Grapefruits
Kiwifruit
Lemons
Limes
Mangos
Melons
Mixed fruit
Nectarines
Oranges, Mandarins etc
Other fruit
Passion fruit
Peaches
Pears
Persimmon
Pineapples
Plums
Pomegranates
Prunes
Raisins/sultanas
Strawberries
Tamarillo

6. PROCESSED FRUIT
Apples
Apricot
Avocados
Bananas
Cherries
Feijoa
Grapes
Kiwifruit
Lemons
Limes
Mangos
Melons
Mixed fruit
Nectarines
Oranges, Mandarins etc
Other fruit
Passion fruit
Peaches
Pears
Pineapples
Plums
Pomegranates
Prunes
Raisins/sultanas
Strawberries

7. FRESH VEGETABLES
Asparagus
Aubergines
Beans (all varieties)
Beetroot
Bokchoy/chinese cabbage
Broccoli
Brussel Sprouts
Cabbages
Capsicum
Carrots
Cauliflowers
Celery
Coleslaws
Courgettes
Cucumbers
Kumara

Appendix 4 – Food categories classified by WasteMINZ (Cont). (10)

7. FRESH VEGETABLES (cont)	Mushrooms	Garlic
Leeks	Onions	Ginger
Lettuces	Other salads	Gravy
Mixed salads	Parsnips	Herbs/spices
Mixed vegetables	Peas (all varieties)	Honey
Mushrooms	Potato salad	Hummus
Onions	Potatoes	Jams
Other raw vegetables	Pumpkin	Mayonnaise
Other salads	Radish	Mustard
Parsnips	Rocket	Olives
Peas (all varieties)	Silverbeet	Other condiments
Potato salad	Spinach	Other sauces
Potatoes	Spring onions	Pickles
Pumpkin	Sprouts	Salad dressing
Radish	Sweetcorn/corn on the cob	Salt
Rocket	Tomatoes	Spreads
Rhubarb	Turnips/swedes	Sugar
Silverbeet	**9. CONFECTIONERY AND SNACKS**	Tomato sauce
Spinach	Biscuits, chocolate	Yeast extract
Spring onions	Biscuits, plain sweet	**12. FATS AND OILS**
Sprouts	Crackers/crisp breads	Butter
Sweetcorn/corn on the cob	Chocolate	Lard
Taro	Confectionery	Margarine
Tomatoes	Nuts	Oils
Turnips/swedes	Other confectionery/snacks	**13. DESSERTS**
8. PROCESSED VEGETABLES	Other crisps	Cheesecake
Asparagus	Peanuts	Chocolate puddings/desserts
Aubergines	Peanut butter	Dairy dessert
Baked beans	Potato crisps	Dessert cakes
Beans (all varieties)	Prawn crackers	Fruit pie/strudel/crumble
Beetroot	Snack bars	Ice cream
Broccoli	**10. DRINKS**	Jelly
Cabbages	Coffee beans	Mousse
Capsicum	Coffee granules	Other puddings
Carrots	Coffee grinds	Trifle
Cauliflowers	Fruit juice	**14. MIXED FOODS - HOMEMADE**
Celery	Milkshake/milk drinks	Composite meal
Coleslaws	Other drinks	Composite snack
Courgettes	Sodas	Composite/other
Cucumbers	Tea/teabags	Instant noodles
Kumara	Water	Sandwiches
Leeks	**11. CONDIMENTS, SAUCES, HERBS AND SPICES**	Soups
Lettuces	Chillis	Stews
Mixed salads	Cook-in sauces	
Mixed vegetables	Dips	

Appendix 4 – Food categories classified by WasteMINZ (Cont). (10)

15. MIXED FOODS - PREPREPARED

Chinese meal, takeaway
Chicken, takeaway
Composite meal
Composite snack
Composite/other
Fish and chips, takeaway
Hamburgers, takeaway
Indian meal, takeaways
Instant noodles
Other ethnic meal, takeaway
Pizzas, takeaway
Sandwiches
Soups
Stews
Sushi

16. OTHER

Baby food
Baby formula
Gunge
Medicinal
Other
Pet food

Appendix 5 – Audit recording sheet by Reynolds and Mirosa (68)

Household ID # :

FULL DESCRIPTION				
Food Type (e.g. corn cob, eaten)			**Weight**	
Comments:			**Preparation State Code**	
PACKAGING ☐ None ☐Opened ☐Unopened				
Weight g	**Pack size & type**	**Date on pack / /**	**☐BB4 ☐Use By**	**Brand**

FULL DESCRIPTION				
Food Type (e.g. corn cob, eaten)			**Weight**	
Comments:			**Preparation State Code**	
PACKAGING ☐ None ☐Opened ☐Unopened				
Weight g	**Pack size & type**	**Date on pack / /**	**☐BB4 ☐Use By**	**Brand**

FULL DESCRIPTION				
Food Type (e.g. corn cob, eaten)			**Weight**	
Comments:			**Preparation State Code**	
PACKAGING ☐ None ☐Opened ☐Unopened				
Weight g	**Pack size & type**	**Date on pack / /**	**☐BB4 ☐Use By**	**Brand**

Appendix 6 – Audit recording sheet used in this study

Supermarket ID: **Date:** **Waste stream:** **Food Category:**				
Food type/ description (i.e. eggs, Frenz 10 pack, broken egg)	**# units Weight/unit (kg)**	**Total weight (kg)**	**Avoidability**	**Date**
	Units: Weight:		☐Avoidable ☐Possibly avoidable ☐Not avoidable	☐Best Before ☐Use by / /
	Units: Weight:		☐Avoidable ☐Possibly avoidable ☐Not avoidable	☐Best Before ☐Use by / /
	Units: Weight:		☐Avoidable ☐Possibly avoidable ☐Not avoidable	☐Best Before ☐Use by / /
	Units: Weight:		☐Avoidable ☐Possibly avoidable ☐Not avoidable	☐Best Before ☐Use by / /
	Units: Weight:		☐Avoidable ☐Possibly avoidable ☐Not avoidable	☐Best Before ☐Use by / /
	Units: Weight:		☐Avoidable ☐Possibly avoidable ☐Not avoidable	☐Best Before ☐Use by / /
	Units: Weight:		☐Avoidable ☐Possibly avoidable ☐Not avoidable	☐Best Before ☐Use by / /
	Units: Weight:		☐Avoidable ☐Possibly avoidable ☐Not avoidable	☐Best Before ☐Use by / /
	Units: Weight:		☐Avoidable ☐Possibly avoidable ☐Not avoidable	☐Best Before ☐Use by / /

Appendix 7 – Semi-structured interview questions used in this study

Questions that will be asked during the interview:

1. What is your definition of food waste?

2. What are your views on food waste within your store?

3. Do you have any processes in-store to minimise waste, if so, what do these involve?

4. Are there any barriers to food waste reduction in your store?

5. How typical is the type and amount of waste observed today of the week, month, year?

6. Do you have any indication as to why certain products are wasted more frequently?

7. What are the main disposal/diversion routes for food waste in your store?

8. Are there any waste diversion routes that you don't use in your store?

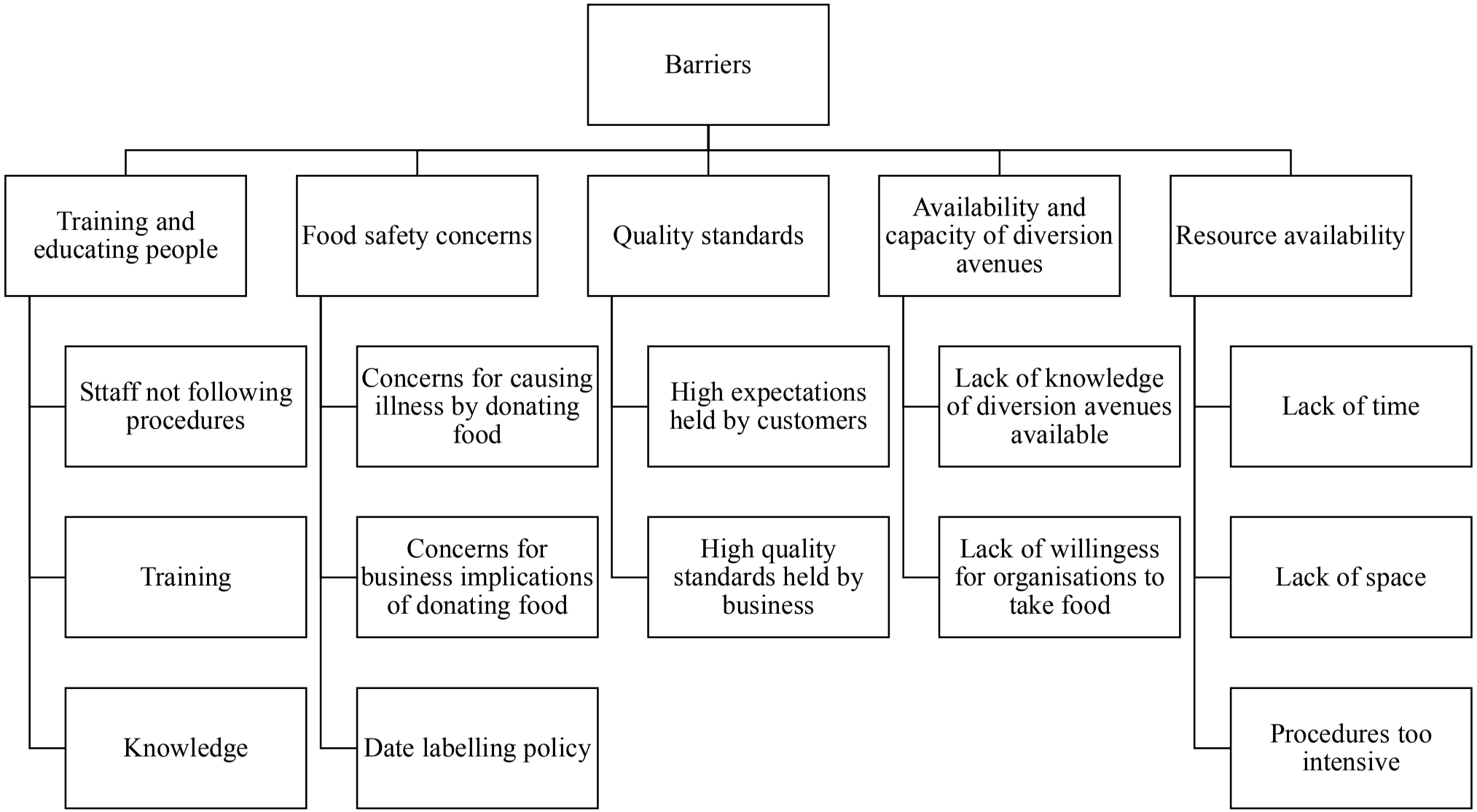
9. What role do customers play the amount and type of food waste generated?

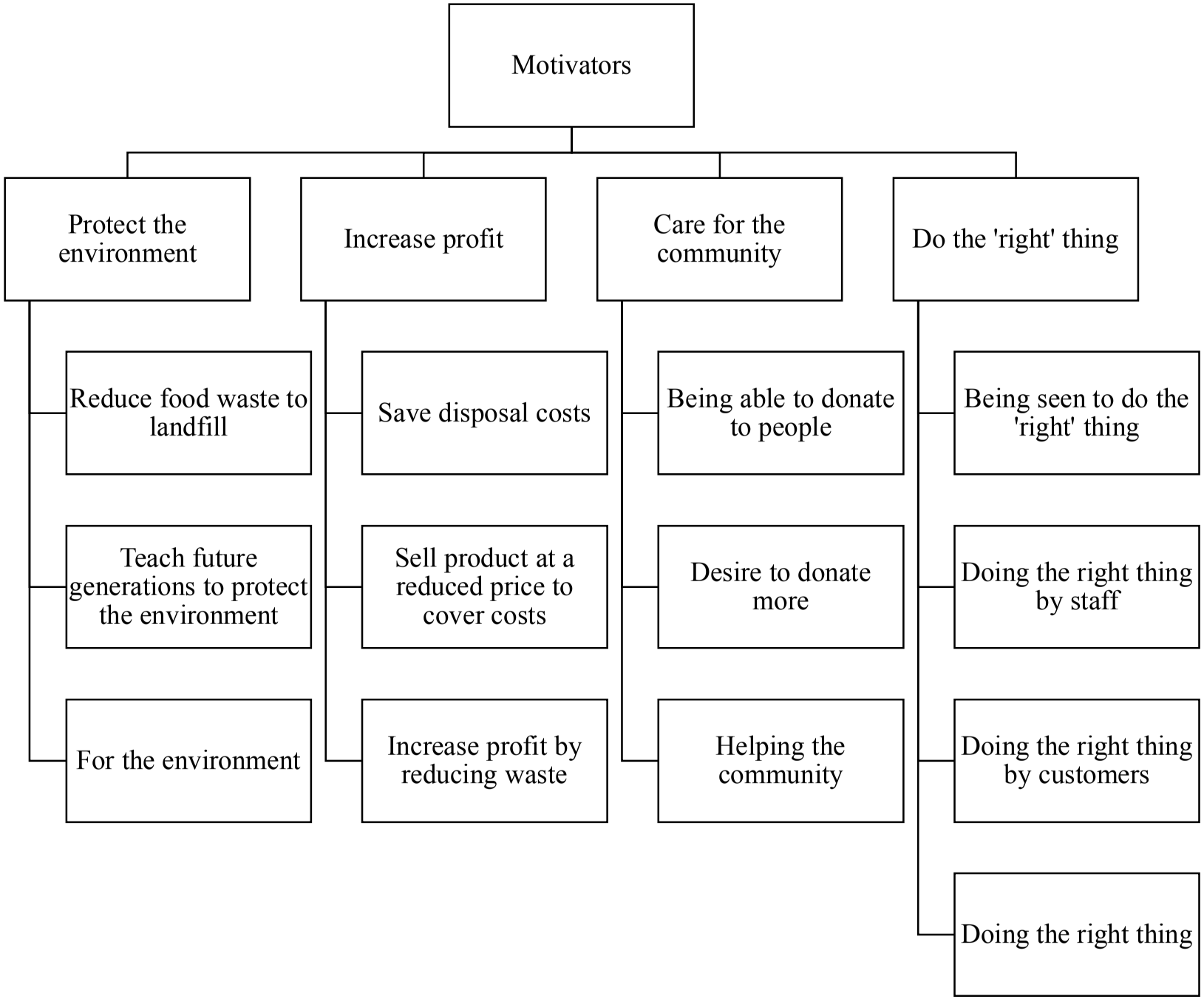
10. What are the issues that need to be considered for any future initiatives regarding food waste?

11. How would decisions concerning intervention implementations be made?

12. What are the key benefits that you associate with food waste reduction in your store?

Appendix 8 – Coding structure used for thematic analysis of semi-structured interviews




Motivators
Protect the environment
Increase profit
Care for the community
Do the 'right' thing
Reduce food waste to landfill
Teach future generations to protect the environment
For the environment
Save disposal costs
Sell product at a reduced price to cover costs
Increase profit by reducing waste
Being able to donate to people
Desire to donate more
Helping the community
Being seen to do the 'right' thing
Doing the right thing by staff
Doing the right thing by customers
Doing the right thing

Appendix 9 – Supplementary tables

Table S1 Weight (kg) and range (kg) for total daily retail food waste and diverted product measured for each food waste and diversion destination

	Total sample (n=16)		Subsample[1] (n=11)	
Destination	Total weight (kg)	Range (kg)	Total weight (kg)	Range (kg)
Animal feed	2338	0 – 602	2240	15 – 602
Landfill	1550	7 – 229	1115	11 – 229
Food donation	1114	0 – 115	737	16 – 115
Protein reprocessing	767	0 – 167	698	0 – 167
Compost	527	0 – 361	48	0 – 48
Total	6296	0 – 602	4838	0 – 602

[1] Exclusive of one store which did not provide complete data and four stores which processed protein offsite

Table S2 Total daily weight (kg) for each food category distributed to each waste or diversion destination for sample (n=11)

	Animal feed	Landfill	Food donation	Protein reprocessing	Compost
Fresh fruit	669	17	99	0	33
Fresh vegetables	1050[1]	64	172[3]	0	15
Meat and fish	0	232[2]	0	698[4]	0
Bakery	493	230	387	0	0
Dairy	16	257	5	0	0
Staple foods	9	124	36	0	0
Drinks (non-dairy)	0	83	31	0	0
All other categories	3	108	7	0	0
Total	2240	1115	737	698	48

[1] 14% product, 86% trimmings
[2] 75% product, 25% trimmings
[3] 100% product, 0% trimmings
[4] 0% product, 100% trimmings