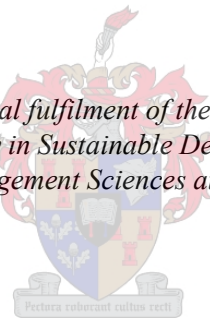# Quantifying Food Plate Waste: Case Study of a University Dining Facility

by

Ochieng' Allan Alooh

Thesis presented in partial fulfilment of the requirements for the degree of Master of Philosophy in Sustainable Development in the Faculty of Economic and Management Sciences at Stellenbosch University

Supervisor: Prof. Umezuruike Linus Opara

March 2015

Declaration

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Ochieng' Allan Alooh

March 2015

Abstract

The quest to tackle food insecurity has never been bigger. However, attaining food security is endangered by the megatrends of a burgeoning population, rapid urbanisation and rising affluence. Projections indicate that the global human population will increase to 9.6 billion in 2050. This necessitates increased food production by 70 percent. Equally, increased human dependency on agriculture means that the global agricultural system must operate in a way that promotes social and economic development. Yet, the current agricultural footprint is threatening environmental sustainability and necessitates reduction. Furthermore, recent investments to enhance food production have only made a modest impact on global food security. In this regard, prudent use of already produced food through minimising food wastage is a practical way of improving food security while limiting the threatening socio-economic and ecological consequences of food waste.

Food Plate Waste (FPW) generated from dining facilities contributes extensively to consumer food waste and is recognised as the highest component of overall food losses and waste. The lack of fairly accurate data on the quantity and composition of FPW has contributed to inefficient waste minimisation measures.

The current study assessed the magnitude, financial cost, causes and level of awareness of FPW in a dining facility at Stellenbosch University, South Africa. During two separate studies, plate waste weight for student diners was measured. A questionnaire was used to establish causes of FPW, students' satisfaction with meals and menus and awareness of FPW as a problem. Results on quantity and cost of FPW were presented in two levels: *only* those students with plate waste and the *entire* dining facility.

Forty-one percent of the total student diners left FPW which amounted to 19.66 kg per day. Mean plate waste among students who left plate waste was 40.42 ± 2.05 percent (mean (± standard deviation) per day whereas the overall plate waste for entire dining facility was 6.35 ± 1.25 percent per day. Average plate waste per student stood at 0.105 and 0.04 kg per day among students with plate waste and the entire dining facility, respectively. The cost of FPW during the studies averaged R480.78 and R117 310.32 per day and annum, respectively. The average cost amounted to R2.56 and R1.07 per day for students who left plate waste and the entire dining facility, respectively. Poor food taste was reported as the single largest cause of FPW followed by poor appearance and inappropriate temperature. Eighty-nine percent of students expressed their awareness of FPW as a problem while more than 75 percent believed that FPW is a problem in the halls of residence. Sixty percent of respondents left FPW while 39 percent of the respondents booked meals but never showed up to dine.

These results indicate that while the magnitude of plate waste for the entire dining facility may be low, the high level of plate waste among students who had plate waste is undesirable. While students may be aware of the negative consequences of FPW, providing regular information to remind them to act in ways that mirror their awareness is key to curbing FPW. These results provide initial and valuable insights into FPW dynamics and hence offer a starting point for discussion on designing and implementing FPW reduction measures within University dining facilities.

Opsomming

Die strewe om voedselonsekerheid te bestry was nog nooit so groot nie. Voedselsekerheid word egter bedreig deur oorhoofse tendense van vergrotende bevolkings, snelle verstedeliking en toenemende rykdom. Daar word beraam dat die menslike bevolking wêreldwyd in 2050 sal toeneem tot 9.6 biljoen, wat 'n 70 persent toename in voedselproduksie sal noodsaak. Gelykstaande hieraan sal toenemende menslike afhanklikheid van landbou vereis dat die globale landbousisteem meer insluitende sosiale en ekonomiese ontwikkeling produseer. Die huidige landbou-voetspoor is egter 'n bedreiging vir omgewingsvolhoubaarheid en moet verminder word. Onlangse beleggings om voedselproduksie te verbeter het verder ook slegs 'n matige impak op wêreldwye voedselsekerheid gehad. In hierdie verband is die verstandige gebruik van voedsel wat reeds geproduseer is deur die vermindering van voedselvermorsing 'n praktiese wyse om voedselsekerheid te bekom terwyl die dreigende sosio-ekonomiese en ekologiese gevolge van voedselvermorsing beperk word.

Voedsel Bord-Vermorsing *(Food Plate Waste (FPW))* wat deur universiteit-eetsale gegenereer word dra op groot skaal by tot verbruiker voedselvermorsing en word erken as die hoogste komponent van algehele voedselverlies en -vermorsing. 'n Gebrek aan akkurate data aangaande die hoeveelheid en samestelling van *FPW* het bygedra tot ondoeltreffende maatreëls vir die vermindering van voedselvermorsing.

Hierdie studie het die omvang, finansiële koste, oorsake en vlak van bewustheid van *FPW* by 'n universiteit-eetsaal by Stellenbosch Universiteit, Suid-Afrika geassesseer. Deur middel van twee afsonderlike studies is bord-vermorsing massa vir studenteverbruikers gemeet. 'n Vraelys is benut om die oorsake van *FPW*, studente se tevredenheid met etes en spyskaarte, sowel as bewustheid van *FPW* as kwessie te bepaal. Resultate aangaande die hoeveelheid en koste van *FPW* is aangebied op twee vlakke: *slegs* studente met bord-vermorsing, en die *hele* eetsaal.

Een-en-veertig persent van al die studenteverbruikers het *FPW* gelaat wat tot 19.66 kg per dag beloop het. Gemiddelde bord-vermorsing onder studente wat oorblywende voedsel gelaat het, was 40.42 ± 2.05 per dag, terwyl die algehele bord-vermorsing vir die hele eetsaal 6.35 ± 1.25 persent per dag was. Gemiddelde bord-vermorsing staan op onderskeidelik 1.105 en 0.04 kg per dag onder studente wat oorblywende voedsel gelaat het en die hele eetsaal. Die koste van *FPW* het op gemiddeld R480.78 per dag en R117 310.32 per jaar beloop. Hierdie gemiddelde koste het R2.56 en R1.07 per dag onderskeidelik beloop vir studente wat oorblywende voedsel gelaat het en die hele eetsaal. Slegte smaak is gemeld as die enkele grootste oorsaak van *FPW,* gevolg deur swak voorkoms en onvanpaste temperatuur. Nege-en-tagtig persent van studente het bewustheid van *FPW* as kwessie getoon, terwyl 75 persent geglo het dat *FPW* 'n kwessie in universiteitskoshuise is. Sestig respondente het *FPW* gelaat, en nege-en-dertig het etes bespreek en nooit opgedaag om dit te verbruik nie.

Hierdie resultate dui aan dat alhoewel die omvang van bord-vermorsing vir die hele eetsaal laag was, is die 'n hoë vlak van bord-vermorsing onder studente wat voedsel oorgelaat het, ongewens. Terwyl studente wel bewus mag wees van die negatiewe gevolge van *FPW*, is die gereelde voorsiening van inligting wat die studenteverbruikers herinner om te handel op wyses wat hulle bewustheid weerspieël, noodsaaklik om *FPW* te bekamp. Hierdie resultate verskaf aanvanklike en waardevolle insig tot *FPW*-dinamika en bied dus 'n vertrekpunt vir die

bespreking van ontwerpe en implementering van *FPW*-verminderingsmaatreëls in universiteit-eetsale.

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To my mum Mary Oyugi, thank you for instilling in me, at a very young age, that 'discarding edible food is a punishable crime', a phrase that kindled in me about research into food wastage.

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To Transdisciplinary Training for Resource Efficiency and Climate Change Adaptation in Africa (TRECCAfrica) consortium, thank you for the scholarship that made possible this research.

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List of Abbreviations

AD	Anaerobic Digestion
BCFN	Barilla Centre for Food and Nutrition
EPA	The United States Environmental Protection Agency
FAO	Food and Agricultural Organisation
FBS	Food Balance Sheet
FPW	Food Plate Waste
FSC	Food Supply Chain
FSI	Food Service Institution
FWRA	Food Waste Reduction Alliance
GDP	Gross Domestic Product
GHGs	Greenhouse Gasses
HEIs	Higher Education Institutions
km^3	kilometres cubed
LCD	Liquid Crystal Display
NHSE	National Health Service Estates
NSLP	National School Lunch Programme
NTS	Non-Traditional Security Studies
OVS	Offer Versus Serve
PHL	Post-Harvest Losses
POS	Point of Service
POSNI	Point of Selection Nutrition Information
RSIS	Rajaratnam School of International Studies
SIK	The Swedish Institute for Food and Biotechnology
SU	Stellenbosch University
UK	United Kingdom
UNPD	United Nations Population Division
US	United States
USD	United States Dollars
USDA	United States Department of Agriculture

USGAO   United States Government Accounting Office

WRAP   Waste and Resources Action Programme

WRI   World Resources Institute

Chapter 1 - Introduction

1.1.   Background and rationale of the research

1.1.1. Food security

The world's food system is at a crossroads. The United Nations Population Division (UNPD) projects that the global human population will increase steadily from 7.2 billion people in 2013 to 9.6 billion by 2050 (UNPD, 2013). Without a doubt, the world's food production system will have to adjust and meet the nutritional needs of this surging population. This in itself is a huge challenge. Accordingly, different proposals on how to feed these teeming numbers exist. The Food and Agricultural Organisation (FAO, 2006) believes there is a need to increase world food production by about 70 percent in 2050 to meet the growing deficit between demand and supply. This suggestion has received widespread support including from the World Resources Institute (WRI, 2012) which further argued that the current food production system cannot, by any means, feed the global human population by 2050.

However, current widespread focus on increased food production as the main strategy to reduce food insecurity has been subjected to a lot of criticism (Soil Association, 2010; Lundqvist et al., 2008) because there is considerable evidence that increasing food production may not necessarily improve global food security (Rajaratnam School of International Studies-RSIS, 2013). It is argued that despite the extraordinary advancements in the agricultural productivity arena over the past century through productive farming methods and improved crop varieties, many parts of the world are still food insecure (RSIS, 2013). The FAO (2014) estimates that globally, approximately 805 million people, alternatively one in nine are chronically undernourished. The situation is worse in sub-Saharan Africa where one out of every four people is chronically hungry (FAO, 2014). Moreover, factors such as rapidly declining soil fertility, climate change (e.g. extreme temperatures, flooding and long heat waves) and the decline of natural resources, all put limits on both current and increased levels of food production (Lundqvist et al., 2008). Put differently, food production cannot be increased indeterminately due to various factors (herein referred to as limits to food production) that come into play. Against this setting, authors such as Lundqvist et al. (2008) encourage increased efficiency in global food supply chain so that more food is accessed by more people in the world; the point being that food insecurity is not just due to lack of production but also is affected by limitations in the distribution system.

Equally, the world agricultural system, now more than ever, needs to provide both social and economic development that is more inclusive (Searchinger et al., 2013). According to the FAO (2013b) approximately 60 percent of the world's population rely on agriculture as a source of their livelihoods. Agriculture contributes up to a staggering 30 percent of economic activity in a number of world's poorest countries (FAO, 2012). Yet, typically, people who work in agricultural sector earn less income which in large part explains high levels of poverty amongst them, notably, those who dwell in the rural areas. Since the majority of the world's poor depend on agriculture, the world's agricultural system must operate in a manner that not only delivers food for consumption but also contribute positively to the socio-economic wellbeing of individual farmers.

Similarly, it is acknowledged that agriculture's ecological footprint is too large and threatens the sustainability of the planet and must be reduced (Searchinger et al., 2013). Agricultural production withdraws natural resources from the environment in huge amounts that cause imbalances in the natural environment. For example, global food production: consumes 70 percent of all freshwater, causes 60 percent of human emissions of methane and 50 percent of nitrogen monoxide, contributes to eutrophication and formation of dead zones (International Assessment of Agricultural Science and Technology for Development-IAASTD, 2009). It is estimated that in 2010 alone, agricultural production contributed 24 percent of the total global greenhouse gas emissions (Searchinger et al., 2013). Increased land clearing for agriculture has been associated with biodiversity loss and ecosystem degradation (IAASTD, 2009).

Clearly, the global food system is at a crossroads. As a solution to this dilemma, the World Resources Institute (2012) explored a range of options, 'menu items' as they refer to them, that must be put in place to synergistically work to avert the impending global food crisis (Searchinger et al., 2013). To qualify to be a menu item, an approach must be one that enhances socio-economic development while concurrently protecting the environment. At the very top of this list of 'menu items' is reducing food losses and food waste. The FAO (2011) also recognises the severity of food losses and has established a high level panel of experts to track the extent of global food losses and waste.

1.1.2. Food losses and waste

Food losses and wastes have been labelled as the most salient yet under recognised global issue that obstructs the road to achieving a food secure world (World Bank, 2011:xii). It is estimated that about 1.3 billion tonnes (30-50 percent) of food produced annually for human consumption does not reach the human stomach and instead is lost in the stages between the 'farm and the fork' (FAO, 2011). These figures are not only stunning but also unacceptable considering that so many people are still undernourished or food insecure.

While extensive resources are being invested globally in increasing agricultural productivity (genetic modification, better farming methods, improved agricultural disease control chemicals), despite the resource and ecosystem limitations, larger gains in food availability could be made simply by reducing food losses. Equally, suggestions have been made to boost resource supply efforts as a means of addressing the limitedness of global food production resources. However, these suggestions have not included resource efficiency, which is crucial for resource sustainability (Agrawal and Nag, 2013). Such efficiency demands both sound resource management and waste reduction.

According to the FAO (2013a), averting food waste decreases utilisation of the natural resources involved in food production. Most importantly, reducing food wastage lessens the threatening ecological and socio-economic impacts related to food wastage disposal. Excluding land use changes, the world's food wastage carbon footprint is approximately 3.3 Giga tonnes of carbon dioxide. This footprint comes third after the United States of America and China (if food produced every year, but not eaten, were a Republic) (FAO, 2013a). It is against this background that reducing food losses and waste is underscored: it enhances the sustainability of the world's food system while simultaneously improving the efficiency in the use of the limited natural resources.

1.1.3. Consumer food service industry and higher education institutions

The consumer food service industry comprises all establishments that prepare and serve meals (food and drinks) out of home, plus for delivery to homes (Nordic Council of Ministers, 2012). The food service industry is sometimes referred to as the hospitality sector. The number of food service outlets varies. For example in Britain, there are about 44,000 food service member establishments that employ 500,000 people. Altogether, these establishments generate an annual turnover of Euros 25 billion (British Hospitality Association, 2014). In the United States of America (US), the food service sector contributes 4 percent of the country's Gross Domestic Product (GDP) and the employees constitute 10 percent of the labour force (Peregrin, 2011). The global consumer food service industry is steadily growing. In 2013 the sectors' value increased by over 4.6 percent over a 5-year period (2008-2013 period) to US dollars 2.6 trillion worth of sales, with Africa, Asia Pacific and the Middle East all showing tremendous growth (Euromonitor International, 2014).

While estimates of the quantities of food waste generated from the hospitality industry exist, significant variations in the estimates has led to contestation of the figures. The differences in the figures has been attributed to disharmonious practices of collecting and using data from only a few sections of the sector as opposed to the whole sector. Nonetheless, significant quantities of food waste are generated from the sector. A study by Engström and Carlsson-Kanyama (2004) found that the Swedish food service industry wastes up to one-fifth of total food purchases. Data for Norway, Sweden, Denmark and Finland combined together reveal that up to 680,000 tonnes of food is wasted annually in these countries (Nordic Council of Ministers, 2012). In the United Kingdom (UK), food service sector generates 0.4 million tonnes of avoidable food waste which economically costs Euros 722 million yearly (Bond et al., 2013). In the US, during the year 2008, food waste in households and food service operations amounted to 86 billion pounds (Gunders, 2012). This equals to 19 percent of the total US retail level food supply (United States Department of Agriculture-USDA, 2011). Overall, these figures represent huge waste of resources and opportunities and as such should be addressed.

Managing plate waste is a concern within the food service industry because it entails costs, which have steadily increased over past years. Among others, costs involved in waste disposal, haul charges, labour, storage locations, equipment rental and containers have been increasing. For example, the cost of disposing one tonne of food in Europe in 1996 was between 20-25 Euros while in 2009 it was 110-185 Euros (WRAP, 2009). Equally, food composting, which is seen as a better option, necessitates use of other resources including in labour, farm equipment and vehicles and land (Whitehair et al. 2008). Put concisely, regardless of the method used, waste management entails use of additional resources. It is against this background that source reduction is seen as the soundest option, both environmentally and socio-economically, for managing food waste.

Among the food service institutions that are characterised with high levels of consumer waste are colleges and universities, collectively referred to as higher education institutions (HEIs) (INFORM, 1998). According to the International Association of Universities (2006), there are over 16,000 HEIs worldwide. Although the traditional HEI was established to provide community with a place to create, communicate and circulate ideas (Wright, 2006), the modern HEI is also involved in the provision of support services, including accommodation, transport, retail, leisure, provision of food and waste management (Zhang et al., 2011).

These services and operations consume significant amounts of resources, notably energy and water, and create large amounts of waste. According to Whitehair et al. (2013) in the United States of America, HEIs generate at least 540,000 million tonnes of food waste each year mainly due to food over-production, fluctuations in sales volumes and poor management of inventories. Moreover, HEIs are extracting resources and emitting wastes at rates higher than the natural environment's ability to cope (Alshuwaikhat and Abubakar, 2008). This has seen a worldwide call for HEIs to reduce their environmental footprint and provide a role model for the rest of society of sustainability practices due to their role and status in society (Stephens et al., 2008; Armijo de Vega et al., 2003; INFORM, 1998).

Although various definitions have been proposed for a sustainable HEI (Alshuwaikhat and Abubakar, 2008), this thesis adopts that put forward by Velazquez et al. (2006:812):

> *"A higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfil its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyle."*

As part of the wider HEI, dining facilities in these institutions are beginning to recognise their role in the sustainability movement through minimising their environmental footprint (INFORM, 1998). Arguably, compared to other campus buildings, campus dining facilities possess the greatest potential for change: they not only consume five times more energy and water compared to other buildings, but also generate five times more waste (Babich and Smith, 2010).

1.1.4. Stellenbosch University

Stellenbosch University, with 27,823 students (Stellenbosch University, 2012), contributes significantly to the total population (18 percent) of Stellenbosch Municipality. As such any food waste reduction measures by the University will go a long way to ease pressure on the municipality's landfills which currently operate beyond capacity (Stellenbosch Municipality, 2012).

Moreover, Stellenbosch University commits itself to integration of sustainability in all its operational processes and functions. In the year 2010, Stellenbosch University Council ratified the Integrated Sustainability Management Policy (Stellenbosch University, 2014). This document did not only establish "an integrated network to guide and coordinate campus activities regarding sustainability" but also committed the University to global practices and principles of sustainable development (Stellenbosch University, 2014:2). Furthermore, this document lists various points of departure. Among them, Stellenbosch University aims at improving its "operational processes and procedures in order to reduce the University's ecological footprint…including the conservation of resources, e.g. by water management, energy management, waste reduction, property management, etc." (Stellenbosch University, 2014:3). Most preciously, the University aims to graduate students with good sustainable development insights, attitudes and practices.

Against this background, Stellenbosch University has initiated various waste reduction programmes focusing on waste recycling (Stellenbosch University, 2014). As a result, huge portions of solid waste material have been made available for recycling thus significantly reducing the quantities of waste being hauled to the landfills. Recycling of organic wastes, specifically food waste, is a challenging process due to the high water content of the waste material. On the other hand, in this quest for waste reduction, there have been limited actions to reduce waste through source reduction. Studies show that waste prevention through source reduction is the single most effective method of waste management (Gunders, 2012).

1.2. Research problem statement, aims and objectives

The lack of accurate and reliable data on the magnitude of food losses and waste is a major constraint in efforts to develop and implement cost-effective food waste minimisation practices. A survey of the literature showed that extensive studies on food losses and wastes, especially at retail and consumer levels, have been carried out mainly in the countries of the developed world, including the (UK) (WRAP, 2009), US (Kantor et al., 1997), Canada (Gooch et al., 2010), Switzerland (Beretta et al., 2013), Australia, Turkey and South Korea (Parfitt et al., 2010). Despite there being high level estimates of the amount of food wasted globally (Gustavsson, 2013; Institution of Mechanical Engineers-IMECHE, 2013; FAO, 2011), very little empirical data exists on actual food wastage at specific parts of the food chain, including food service institutions (RSIS, 2013; Griffin et al., 2009). Thus, the environmental impacts and the socio-economic values of food losses and wastes within the lower stages of the food supply chain are generally unknown (Barilla Centre for Food and Nutrition-BCFN, 2012). Moreover, the absence of fairly accurate data on the magnitude and extent of food wastage obstructs design and execution of food waste minimisation measures (FAO, 2013a).

The literature survey also reveals that in South Africa, very few studies have examined the dynamics of consumer food waste, specifically around higher learning institutions. In fact, there are only two reported national studies of food waste in South Africa. The first study by Oelofse and Nahman (2012) estimated the magnitude of food waste generated in the entire country (South Africa) while the second one by Nahman et al. (2012) quantified and valued post-consumer food waste at the household level. In both studies, food waste in the food service industry was not considered. Furthermore, both studies did not did not include primary data collection but rather the researchers used food loss factors[1] to estimate food waste quantities and, like many previous researchers, recommended further research to verify their results through primary data collection (Gustavsson et al., 2013; Beretta et al., 2013; Kantor et al., 1997). The use of food loss factors to determine food wastage has however been questioned. Griffin et al (2009) argue that food loss factors do not give accurate estimates of food wastage.

This implies that measures to reduce food waste in South Africa's higher learning institutions are often discussed based on research conducted in other countries, mainly in the developing world. However, Beretta et al. have cautioned that amounts of food losses and wastes vary with "agricultural infrastructure, food processing technologies, climatic conditions and income" (2012:772-773). Thus, food waste statistics cannot be crudely extrapolated from one country

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[1] For a full discussion on food loss factors see section 2.4.2

to another, except where the locations in question have comparable economic and climatic conditions as well levels of technological advancements in postharvest food management. However, the methods used in estimating food waste can be applied universally (Beretta et al, 2012).

Moreover, South Africa has two parallel economies; one that matches those of developed countries and another characterised by only the most basic infrastructure. This two-tiered structure is also evident in the country's agricultural system. While the majority of farmers in the developed world perform small scale operations, most South African farmers perform large scale operations (Oelofse and Nahman, 2012). Thus, South Africa's agricultural system is a hybrid of those of developing and developed countries.

Minimising food waste by way of source reduction is a complex process that requires the working together of all the agents that handle food from 'farm to fork'. Within food service institutions (the focus of this thesis), source reduction entails institutionalisation of strategies that limit quantities of waste generated during food preparation: kitchen waste, and during consumption: plate waste. Execution of these strategies can only be possible if fairly accurate data on the amount of and reasons for food waste are established. Therefore, this study aimed to provide *primary* data on the magnitude, causes of, and cost of food plate waste in Metanoia[2], a students' residential facility within Stellenbosch University.

1.2.1. Research aim

The aim of this study was to assess the level of food waste in a university residential dining facility.

1.2.2. Research objectives

The specific objectives were to:

1. estimate the amount of food plate waste generated in a students' dining facility (Metanoia) at Stellenbosch University, South Africa,
2. estimate the financial value (cost) of food plate waste in this dining facility,
3. determine the causes of food plate waste in this dining facility, and
4. assess the level of awareness about plate waste among the students.

1.2.3. Key concepts and definitions

This section provides definitions of the key terms and concepts as used in this thesis. Where relevant, these terms are further explained in the appropriate sections later on.

Food loss: indicates a reduction in mass (quantity) and/or nutritional significance (quality) of food, thus making food originally intended for human consumption unfit for consumption. Food losses are mainly associated with inefficiencies within the Food Supply Chain (FSC). These include: poor/inappropriate logistics and infrastructure; insufficient knowledge, skills and technology by the actors along the FSC. In some cases, changes in weather patterns and natural disasters influence food losses (FAO, 2013a).

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[2] Metanoia is the largest students' residential facility within Stellenbosch University main campus, with capacity for 501 students (Tutu, 2014).

Food waste: indicates food that is fit for human consumption that is discarded before consumption, mainly because the food has expired or was consciously or unconsciously left to spoil (FAO, 2013a).

Food wastage: indicates food lost either through deterioration (in quantity and quantity) or discard. Accordingly, 'food wastage' includes both food losses and food waste FAO (2013a)

Food leftovers: refer to food which is prepared but never served (Engström and Carlsson-Kanyama, 2004).

Serving losses: refer to food that is left on preparation and/or serving utensils (spoons, dishes or bowls (Youngs et al., 1983).

Food Plate Waste (FPW): denotes food that is served but left uneaten and discarded (Connors and Rozell, 2004). Elsewhere, plate waste is also referred to as post-consumer food waste or 'table scraps' (LeanPath, 2012).

Food supply chain: a system of organisations, people, and activities that moves food from its initial producer (ordinarily the farmer) to the final consumer (Beretta et al., 2013; Mena et al., 2011).

1.3. Significance of the study

This study will help in understanding food plate waste dynamics in a major dining facility (Metanoia) and other dining facilities within Stellenbosch University that use similar food catering arrangements. By determining a fairly accurate quantity of food wasted, and the monetary cost associated with the waste, this research provides useful information for performing cost-benefit analysis of eliminating FPW from the dining facility.

Furthermore, information from this research will inform decision making processes during designing and implementation of food waste reduction strategies, with the overarching logic being that there is no effective food waste reduction measure that can be developed without knowledge of fairly accurate information on the magnitude of food waste and the causes of such wastes. Information on students' beliefs and awareness of food plate waste will be crucial in carrying out consumer education – a key measure to eliminating food waste.

1.4. Introduction to research design and methodology

A survey was chosen as the soundest research method to address the first two objectives. Objective 1 is empirical in nature as it necessitates carrying out actual weight measurements of food plate waste: primary data collection, while objective 2 used findings of objective 1 to be fulfilled (see Chapter 3 for full methodology description). Primary data collection has an advantage as it provides data that may not be available from other existing sources (e.g. existing literature) (Rozakis, 2004). Surveys have an advantage in that they have the potential to be generalised to large populations provided that appropriate sampling design has been executed (Mouton, 2012).

To tackle research objectives 3 and 4, a structured questionnaire was used to collect data. The contents of the questionnaire were quantified and analysed to show descriptive statistics; regression, mean, mode and interquartile range. Data was presented in tables, bar graphs and

pie charts. While a properly constructed and validated questionnaire increases reliability of survey's findings, questionnaires may not provide deep insider perspectives that may be obtained through interviews (Mouton, 2012).

1.5. Outline of the thesis

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│            APPENDICES                          │
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Figure 1.1 Outline of the thesis and chapter contents

Chapter 2 - Literature review on food losses and wastes, with particular focus on plate waste

2.1. Introduction

This chapter reviews the literature on food losses and wastes. Firstly, a historical overview and definition of food losses and waste is provided. Subsequently, causes and examples of food wastage along the food supply chain are presented. Due to the specific relevance of consumer food waste to this thesis, the magnitude of and reasons for food waste at the consumer level are discussed. This is then followed by a review of socio-economic and ecological consequences of food wastage. To put the current study into context and enable its comparison with previous studies, a review of food plate waste in selected food service institutions is presented. Special focus is paid to methodologies used to measure food waste and the socio-economic impacts. Next, an examination into reasons for plate waste in universities dining facilities and some successful strategies that have been used to reduce them is reviewed. Lastly, considering that food plate waste cannot be completely eliminated in foodservice, literature evidence on the creation of new value from food plate waste is presented.

2.2. Food losses and wastes: historical overview and definition

The problem of global food losses and waste has attracted ongoing attention for a significant period of time. The article by Atwater (1895) was arguably one of the earliest pointers of food waste. While this study focused mainly on chemical composition of human food and its nutritional aspects, such as the proportion of inherent nutrients, food digestibility and energy values, it provided quantitative information on food waste and recommended further investigation into the dynamics of food waste. When the FAO was formed in 1945, one of its mandates was to reduce food losses and wastes. When the first World Food Conference (WFC) was held in 1974, global post-harvest losses were estimated to be about 15 percent of global food production and yet deemed a challenge to curbing food insecurity (Schneider, 2013). This prompted the Conference to set a target of a 50 percent reduction in post-harvest losses by the year 1985 to improve world food security (Parfitt et al., 2010).

Although there is no account of the progress on the 1985 target, Schneider (2013) assesed academic publications since the 1980s and saw the comeback of food waste prevention issues. However, Schneider (2013) argues - based on the numbers of scientific works and increasing inclusion in local and global political agenda - that it is only from 2005 that food losses and wastes received wide attention. Kantor et al. (1997) attributed this attention to the increasing concern about hunger and resource conservation, and the burgeoning economic and environmental costs associated with food waste. Unlike the earlier attention on post-harvest losses, this renewed interest now places special focus on waste at the consumer level. The FAO (2011) estimated that global consumer food waste constitutes 35 percent of the overall food

wastage. Due to this great magnitude, reduction of consumer food waste has been accorded the highest priority in the general fight against food losses and wastes (FAO, 2013a).

A universally accepted definition of food losses and wastes does not exist (Schneider 2013). The FAO (1981) (in Parfitt et al. 2010) first defined food losses as the wholesome loss, discard, degradation or consumption by pests of edible material that was originally intended for human consumption. This means that food losses and wastes include any occurrence along the food supply chain that ultimately reduces the total amount available for human consumption. Gustavsson et al. (2011) adopted the definition by the FAO and went further to include all food products employed in non-food use such as animal feed or in the production of bioenergy.

Smil (2004) applied a nutrition perspective to the analysis of food wastage and defined over-nutrition as the difference between the energy value of consumed food and the energy value of food needed, both calculated on a per capita basis. The bigger the gap, the higher the amount of food loss and waste. Due to the contribution of over-nutrition to increasing incidence of non-communicable diseases such as obesity, researchers agree that the concept of over-nutrition deserves a closer look in efforts to address the twin challenges of food insecurity and human health (Parfitt et al., 2010; Blair and Sobal, 2006). This is an interesting angle, but will not be pursued further as it is outside the scope of this study.

In this thesis, the definition of food wastage as proposed by Bond et al. (2013:3) is adopted. They define food losses and wastes as "edible food products, which are intended for purposes of human consumption, but have instead been discarded, lost, degraded or consumed by pests, and does not include the inedible or undesirable portions of foodstuffs." A close examination reveals that this definition is an amalgamation of the above definitions, thus, it adequately describes food losses and wastes.

Although the terms 'food losses' and 'food waste' have been used interchangeably in literature, in a strict sense they have different meanings (Parfitt et al. 2010). Food losses refers specifically to reductions in quality or quantity of food which makes it unsuitable for consumptions by humans (FAO, 2011), whereas food waste refers to food that is of desirable quality and fit for human consumption but is instead discarded before or after it spoils (Lipsinki et al., 2013). According to Lipsinki et al. (2013), food losses result from spills, spoils or uncharacteristic reduction in food quality, including bruising or wilting that altogether reduces the quantity of food that reaches the final consumer. Although food losses and wastes occur throughout all phases of the food supply chain i.e. from production to consumption (Gustavsson et al., 2011), food losses are typically limited to the early phases i.e. during and after harvest (Bond et al., 2013), hence the term post-harvest losses. Post-harvest losses are mainly due to insufficient or inefficient technical aspects of agricultural production like the lack of appropriate infrastructure for produce harvesting, processing, packaging, storage, or marketing (World Bank, 2011).

Food waste typically results from activities and operations at food consumption points i.e. the last and final phases of the food supply chain (retail and final consumption) (World Bank, 2011). Beretta et al. (2013) argue that food waste results from negligence or an intentional decision to discard food and is therefore related to consumers' attitudes and behaviours towards the food they buy to consume. A general understanding exists in literature that food losses predominantly occur in less developed countries whereas food waste is seen as a problem in industrialised countries (Gustavsson et al., 2013; Lipinski et al., 2013; Parfitt et al., 2010).

The most commonly used categorisation of consumer food waste is provided by the Waste Resources Action Program-WRAP (2009). According to their grouping, three main categories exist: avoidable, possibly avoidable and non-avoidable food wastes. Avoidable food wastes includes all perfectly edible food that is discarded before consumption. This category includes food that some individuals eat while others consider inedible, such as bread or pizza crusts. Certain food types, for example potato skins, are classified as possibly avoidable wastes because some people eat them when they are prepared in a given way and not in another way. The unavoidable wastes category includes inedible food items that are unfit for human consumption like meat bones and egg shells.

Food losses and wastes occur throughout the food supply chain, from production to processing and packing-manufacturing, to distribution and the market and consumption (Engstrom and Carlsson-Kanyama, 2004; Kantor et al., 1997). Table 2.1 is a summary of the main phases of the food supply chain and the characteristic examples of food losses and wastes.

Table 2.1 Causes of food losses and wastes along food supply chain

Food supply chain phase	Examples and reasons of food losses and wastes
Production	• Economic reasons - deliberate non-harvesting or selective harvesting due low market prices which may not equal production and harvesting costs • Destruction by natural disasters or damage by insects or predators • Overproduction • Inadequate or inappropriate harvesting technology • Poor harvest timing which results in degradation in crop quality or quantity • Natural drying out of food; bruising and spoiling
Manufacturing-processing and packing	• Culling products through specified criteria such as quality or appearance, size, weight, colour or blemish level • Inappropriate processing and packaging technologies • Primary processing - cleaning, de-hulling, pounding, grinding, packaging, soaking, winnowing, drying, sieving, milling • Secondary processing - losses during industrial milk and juice processing • Peeling, slicing, cutting, cooking
Distribution and at the market	• Incorrect produce handling and transportation • Overstocking and insufficient stock rotation • Produce expiring before consumption
Consumption	• Inappropriate food handling and storage; poor stock management • Losses during food preparation; kitchen losses and leftovers • Bulk and impulse buying • Poor planning during shopping and cooking • Over preparation of meals • Poor food preparation techniques • Plate waste • Storage losses • Misunderstanding of label dates ('best before' and 'use by' dates)

 (Adapted from Lipinski et al., 2013; Gunders,2012; Parfitt et al., 2010; Griffin et al., 2009; Kantor et al., 1997).

2.3. Consumer food waste: magnitude and causes

Although studies report different figures for losses and wastes in the various stages of the food supply chain, they all agree that consumer food waste is the greatest contributor to overall food wastage (Gustavsson et al., 2013; Gunders, 2012; FAO, 2011; Kantor et al., 1997). Kantor et al. (1997) reported that food waste in households and food service institutions constitute 26 percent of the total waste. In America, an average family (consisting of four people) throws away up to 25 percent of their food and beverage purchases and this is estimated to cost between US dollars 1,365 and 2,275 yearly (Gunders, 2012). In the UK, it has been estimated that an average household can save Euros 480 per year if they minimise their avoidable food

losses and this figure represents 15 percent of their total expenditure on food and drink (WRAP, 2009).

An evaluation of literature reveals that consumers waste between 4 and 60 percent of total food volumes they purchase (Gustavsson et al., 2013; Schneider, 2013; Gunders, 2012; Williams and Walton, 2011; Stuart, 2009). However, different regions show different food waste quantities. For example, while South African consumers food waste constitutes only 4.1 percent of the country's total food wastage (Oelofse and Nahman, 2013), food waste among German consumers account for 61 percent of the country's total wastage (Caronna, 2011). Griffin et al. (2009) analysed one US community food system and found out that consumers generated 60 percent of the total food waste. Although the study by Caronna (2011) (on food wastage in Germany) did not estimate food waste at the production phase. All food waste figures cited in this paragraph highlight two factors; first, the more affluent a country is the more the consumers tend to waste food, second, in developed countries, major efforts aiming at reducing global overall food waste should be directed to consumers since the greatest potential remains with them.

Different reasons have been attributed to the high percentage food waste by consumers in the world's most affluent societies. Firstly, in industrialised nations consumers have constant access to cheap food (Gunders, 2012). As such food expenditure represents only a small portion of consumers' budgets. Therefore, the monetary cost of purchasing food is far too low and do not match food's convenience. Therefore, consumers tend to discard food rather than conserve it. Secondly, along the food supply chain, downstream food waste means more income for any actor upstream. The more food is wasted by consumers, the higher the sales volume and income for the producers and retailers (Gunders, 2012). In the emerging world economies, a different reason exists. These countries are characterised by growing technological and economic development and urbanisation. Therefore, a need exists to provide food for this increasingly affluent population. During the transition of food supply chains to meet this requirement, more food is wasted primarily as a result of poor infrastructure and management (Foresight, 2011).

2.4. Consequences of food losses and waste

2 4.1.   Social consequences

There is an argument that it is morally unacceptable that, in a world where so many people go to bed hungry, so much food is lost and wasted (Mena et al., 2011). Cribb (2010) refers to this as a tragic irony wherein approximately one billion people go to bed hungry when annual total food wastage can feed three billion people for the same period of time. In the US for example, food wastes stands at 9.1 kilograms per person per month. Yet, "one in six Americans lack a secure supply of food to their tables" (Gunders, 2012). Stuart contends that both the poor and the rich countries are essentially buying food from the same common source; therefore, "if rich countries buy hundreds of millions of tonnes of food and end up throwing these into the bin, they are gratuitously removing food from the market which could have remained there for other people to buy" (2009:1).

According to Cribb (2010) food insecurity is to blame for major global insecurity including war which causes constant human displacements. Cribb contends that cutting global food losses and waste would make the world a better and more peaceful place. Every nation, regardless of

their affluence has a role to play. Additionally, it should not be forgotten that food losses and waste means nutritional waste. Nutritional waste increases food insecurity and chronic hunger which in turn escalates peoples' susceptibility to disease and lethargy, decreasing their capability to work. Furthermore, nutrition has been identified as the foundation for human and economic development. For example, adequate nutrition enhances development through poverty reduction, improving educational outcomes and reducing child mortality (FAO, 2014). Clearly, the aggregate costs associated with food waste and nutrition insecurity thwart efforts to promote quality economic growth and general welfare.

2 4.2. Ecological consequences

The ecological consequences of food losses and wastes are immense and worrying. Firstly, food waste represents unnecessary greenhouse gas (GHG) emissions. The activities along the food supply chain are characterised by energy consumption and emission of GHGs. According to WRAP (2008), a *single* tonne of food waste is liable for 4.5 tonnes of carbon dioxide. When trucked to landfills, food decomposes into methane - a gas that is at least twenty times more potent than carbon dioxide for global warming (Mena et al., 2011; Hall et al., 2009). When buried, decaying food causes air and water pollution through surface runoff and leaching (Griffin et al., 2009). These impacts exclude those of crop production which include alterations to natural landscapes and ecosystems, biodiversity loss and increasing the global temperatures, which are not easy to quantify (FAO, 2013a; Lipsinki et al., 2013).

2 4.3. Economic consequences

Economically, food losses and wastes represent poor investment of resources; food waste is tantamount to money squandering. The FAO (2013a) estimated that in 2013, the global cost of producing uneaten food stood at US Dollars 750 billion; equivalent to Switzerland's GDP. According to Gunders (2012:1), even as 40 percent of food produced in the US goes uneaten, food production "eats up 10 percent of the total US energy budget, uses 50 percent of US land, and swallows 80 percent of freshwater consumed in the United States". Although the costs vary between regions and countries, food losses and wastes significantly eat into virtually every nation's resources. Gooch et al. (2010) estimates that food losses and wastes accounts for at least 2 percent of Canada's GDP. Albeit small, investing this 'wasted money' into different projects that can create common good for the greatest number of people would undeniably make more sense.

In some countries, the situation is worse. Food is not only expensive to buy but also to dispose of. Principally, moving food from farm to fork involves costs including the initial cost of raw materials, transport, storage, preparation and cooking costs (staff and energy costs) (Whitehair et al., 2013). Typically, these costs are passed down to the final consumer. Hence, the higher the overall cost, the higher the price of food. Still, there are disposal costs attached to food waste. Every actor along the food supply chain, whether it is the producer or the consumer, has to pay this cost. Definitely this is a burden to the consumer and for other actors: it eats into business profit. Also, these costs are rising steeply. In 1996, disposing one tonne of food in Europe cost between 20 and 25 Euros while in 2009 it was 110 to 185 Euros (WRAP, 2009).

Food losses and wastes also represent economic losses. Losses mean significant but avoidable inefficiencies in the use of the limited natural resources. For example, whereas global food production consumes up to 70 percent of the total freshwater use, more than one quarter of this

percentage is used to produce 'food for waste' (Hall et al., 2009). Figures released by the FAO (2013a) show that wasted food consumes some 250 km^3 of water on an annual basis and occupies almost 30 percent of the world's agricultural land. Worse still, agriculture consumes conspicuous amounts of one of the most crucial yet limited resources: oil. Before including oil consumed during food transportation and processing, Hall et al. (2009) estimated that in the US, wasted food consumed 300 million barrels of oil annually, which represents 4 percent of overall US oil consumption.

Clearly, by all standards, food is too costly to waste. Considering both the quantities of resources invested in food production, and the negative consequences of food losses and waste, every mechanism necessary to abate food losses and waste needs to be urgently instituted. Significant financial savings can be made by limiting food waste, for example through reduced disposal costs. This way, businesses can increase their profit margins. Likewise, farmers can significantly increase their profit margins by simply selling food that is left as waste. Stuart (2009) argues that just by increasing their levels of efficiency during food handling, retailers can defeat their rivals who are inefficient. In the same manner, manufacturers can reduce their operational costs purely by tackling food waste.

Similarly, households can also save money by cutting down on their wastes. But again, mankind cannot continue wasting food (and nutrients in them) forever when we all know that we live in a world with finite and exhaustible resources (Cribb, 2010). The awareness of this fact unambiguously calls for effective management of food that is already produced at every level of the food supply chain.

2.5. A review of methods used to quantify food losses and wastes

2.5.1. Introduction

Globally, several studies have assesed the quantities of food losses and wastes, notably in the developed world (FAO, 2013a; Parfitt et al. 2010; Kantor, et al., 1997; WRAP, 2009). However, widely different quantities of food waste have been presented and some would appear to contradict one another; hence there has also been contestation of the results. The methodology used in food waste study has a bearing on the findings (Lebersorger and Schneider, 2011). Schneider (2013) contends that the methodology adopted for quantifying food waste dictates the qualification of the results and the impacts of these results. Youngs et al. (1983) maintain that the absence of a worldwide harmonised food waste quantification methodology and a standardised way of displaying results introduces the problem of comparability. Obviously, poor comparability of studies and results greatly reduces execution of similar studies in the future. This undersores the importance of a food waste study precisely describing its methodology and scope of investigation while delineating the underling assumptions and limitations.

Comstock et al. (1979) categorise food waste measurement methods into two main groups: indirect and direct measurements. Indirect methods for food waste quantification include self-estimation and visual estimation. Self estimation entails consumers reporting, if they can remember, the amount of food that they consumed and wasted. In the in visual estimation, trained investigators evaluate amount of food waste by way of sight.

Reliance on consumers' ability to remember the amount food they wasted has been attributed to the low degree of objectivity, repeatability and hence poor reliability of these studies (Williamson et al., 2003; Comstock et al., 1979). When they self-report, consumers may under-report the amount of food they consumed or wasted. Furthermore, indirect methods use terminologies, scales and gradations that require initial pretesting before the actual test. This makes indirect methods expensive. According to Comstock et al. (1979), the suitability of a food waste quantification method is dictated by its reliability, validity, cost, level of interference with daily cafeteria routines and range of applicability. Moreover, a method needs be compatible with the various menu items and serving systems used in cafeterias.

Direct methods entails capturing the actual quantity of the wasted food items directly. The most common direct method is weighing. A survey of literature (Lebersorger and Schneider, 2011; WRAP, 2009; Williamson et al., 2003; Kirks and Wolff, 1985) revealed that four main direct methods have been used to estimate the magnitude and composition of food waste. These include: diary keeping; archaeological excavations and garbage analysis; inferential methods and plate waste. The following section briefly descibe these methods.

2.5.2. Archaeological excavations and garbage analysis method

Archaeological excavation is arguably the oldest method of estimating food wastage. Harrison et al. (1975) were perhaps the pioneers of this method when they used it to assess food waste behaviour of an urban population in the US. This method entails examination of waste streams to quantify food but not drink waste. Waste streams are the sources of wastes generated by the various actors along the food supply chain (WRAP, 2009). They include general wastes (thrown into bins), food waste collections by local authorities, home composting, food waste thrown in sewers among others. Generally, garbage analysis entails initial manual sorting out the contents of garbage containers and/or landfills to separate food waste from general waste. To determine the proportion of food consumed or otherwise wasted, researchers estimate food inputs (mainly food purchases) into the study area and subtract from this figure the amount of edible food collected from the waste streams (Comstock et al., 1979).

The main advantage of this method is that it provides useful quantitative data on the magnitude of food waste of a specific region. However, it has several disadvantages. Firstly, sorting out of food waste from general trash is resource intensive and hence expensive (Comstock et al., 1979). Moreover, during the sorting, it is difficult to assign the landfilled food waste to their sources. For example, it may be impossible to know if the food waste came from manufacturers, retailers or consumers. This makes it difficult to prioritise, design or implement food waste minimisation measures (Griffin et al., 2009).

Secondly, relying on data on food supplies or purchases by consumers in the study area makes this method more responsive and increases its levels of inaccuracy. According to Comstock et al. (1979), food supplies figures do not represent absolute amount of food consumption. Lebersorger and Schneider (2011) argue that not every food purchased is ultimately consumed by households: some food may be fed to animals, consumed by pests or disposed via other non-analysed waste streams e.g. sewers. Moreover, in some cases, consumers acquire food directly from their gardens. Typically, food from consumers' gardens are not included in the overall consumer food input data. Sometimes, consumers from outside the study area may purchase

food from the study area (Griffin et al., 2009). In totality, an underestimation of the total food consumed may occur.

2.5.3. The statistical/inferential method

This method involves using national, regional or global data on food supply and consumption to estimate food losses and wastes (Gustavsson et al., 2013). As Griffin et al. (2009:69) puts it, inferential methods "use food waste factors derived from diary, plate analysis, and material culture research to calculate food waste". In some cases, waste factors may be directly obtained from scientific publications and assumed to accurately represent food losses and wastes. For example Rathje and Murphy (1992) carried actual measurements of household food waste through analysis of garbage cans and landfill excavations in the US. They found that every household member wastes an average of 2.5 ounces of food. This figure was used by Griffin et al. (2009) as a food waste factor to quantify food wastage of a community food system.

The inferential method has been the most extensively used to determine food wastage at national, regional or global scales. The Swedish Institute for Food and Biotechnology on behalf of the FAO used this method to quantify global food losses and wastes (Gustavsson et al., 2013). They used information on food volumes produced (based on FAO food balance sheets and weight percentages of food wastage as gleaned from existing literature), and made assumptions and estimations to fill data gaps (Gustavsson et al., 2013). It is this study that found out that 'up to 30-50 percent of global food produced for human consumption is wasted'- one of the most cited statistics on food losses and wastes publications. Food loss factors developed by Gustavsson et al. (2013) have been used widely, including in South Africa to estimate the magnitude of food losses and waste (Oelofse and Nahman, 2012, Nahman et al., 2012).

WRAP (2009) also used the inferential method and estimated that UK households discard up to seven million tonnes of food per annum. This was said to be costing the UK's economy about Euros 10.2 billion and households Euros 480 per annum. Similarly, Hall et al. (2009) employed the inferential method to arrive at the estimate that up to 40 percent of food produced in the US is wasted annually.

Besides application in global, regional and national and studies, the inferential method has also been used to quantify food wastes in food service institutions. Youngs et al. (1983) applied this method to examine the extent of food waste from hotels and restaurants in the UK. Representing the quantity of food wastage by energy basis, they found a waste of 30 to 33 percent of food input in hotels and 3 percent in restaurants.

The inferential method has several advantages. Firstly, it is unobtrusive and non-reactive: consumers do not know that their food behaviours are being examined and therefore do not alter them (Engstrom and Carlsson-Kanyama, 2004; Gallo 1980). This increases the chances of finding genuine results. Secondly, it permits broad scope examination of various aspects of food utilisation (Griffin et al., 2009). For example, food nutrition activities from the production phase to nutrient utilisation can be established. In this way, a more comprehensive estimate of food waste across the entire food system can be established. Thirdly, the inferential method permits rapid assessment of food waste as it uses readily available information (Griffin et al., 2009). Thus, results from this method may be more robust as they are not influenced by the

limitations associated with the use waste factors that are generated from only a sample but applied to overly large populations (Hall et al., 2009).

The inferential method has limitations too. First, usually, it uses food balance sheets whose accuracy has been questioned, notably for developing country's wherein food consumption mainly relies on subsistence agriculture (Hall et al., 2009). A food balance sheet describes the patterns of a region's food supply over a specific time period (Gustavsson et al., 2013). In developing countries, contrary to developed ones, tracing and accounting for food products is a difficult process characterised by high chances of error since signficant food quantities hardly enter the market place (Hall et al., 2009). Second, the inferential method may give inaccurate results since it is prone to cumulative errors (Hall et al., 2009). For example, indiscriminate application of a food waste factor that is specific to a phase of the food supply chain to other phases may create imprecision in results. As Griffin et al. (2009) argues, even similar studies focusing on the same phases of the food supply chain may be characterised by dissimilar waste loss factors.

Third, although the inferential method permits rapid assessment of food losses and wastes especially in cases where primary data on food waste is limited, it relies heavily on historical data. Its reliability is therefore questioned since most community food systems are not static: consumption changes occur in the food system over time (Griffin et al., 2009). Therefore, there is a need to develop new food waste factors regularly to make the inferential method reliable and precise.

Fourth, the inferential method assumes that the unit of analysis, e.g. a community, is a closed system. This may not necessarily be the case since even within a community food system, it is not easy to "differentiate waste from residents and non-residents" (Griffin et al., 2009:78). Hence, data used in the inferential method may be skewed. However, this argument can be countered by asserting that similar processes i.e. extensive mobility and migration occur in the neighbouring communities and as such, the effects balance out.

2.5.4. Diary keeping method

This involves recruiting study participants to record the types and amounts of food and drink they waste by weight or volume. Usually, the reasons behind such wastes are documented too. According to WRAP (2009), diary keeping is the most reliable way of quantifying wastes that cannot be quantified through compositional analysis. It is for this reason that diary keeping has been applied worldwide for a long time incuding in the recent past (Griffin et al., 2009; WRAP, 2009; Wenlock et al., 1980; Adelson et al., 1963).

The possibility of study participants changing their wasteful behaviour during the study period is the greatest disadvantage of diary keeping method. This may lead to arrival at inaccurate findings and conclusions as consumers may discard less food than they usually do. Moreover, diary keeping is significantly responsive. This means its reliability is closely tied to consumer honesty and memory, that is, consumers must be able to remember and record all food they waste (WRAP, 2009).

2.5.5. Plate waste method

Williams and Walton (2011:240) define plate waste as the "volume or percentage of the served food that is discarded". Thus, the plate waste quantification method involves examination of food left on the plates by the consumers when they are done eating. By subtracting the amount of food left on the plate from the amount that was served, the quantity of food wasted is derived. Findings from plate waste studies are by and large presented to show the proportion, by weight, of the served but uneaten food. Otherwise, depending on the objective of the research, results from plate waste studies may be used to show energy, protein, or financial losses associated with the waste (Williams and Walton, 2011).

The plate waste method has been mainly used to estimate the amount of food waste in food service institutions (Cohen et al., 2013; Williams and Walton, 2011; Kelly, 1999; Comstock et al., 1979). Additional aspects that have been evaluated using this method include: the effect of environmental factors on food consumption; the financial cost of food waste; monitoring menu performance and understanding the effect of the type meal service on plate waste. Table 2.2 provides a summary of randomly selected studies (conducted around food service institutions) that have examined these aspects.

Table 2.2 Selected aspects investigated by plate waste studies in food service institutions

Reason for plate waste study	Examples of studies
Quantify food plate waste	[1]Comstock et al., 1979; [2]Huls, 1997; [2]Kelly, 1999; [4]Al-Domi et al., 2011.
Effect of environmental factors on food consumption	[1]Yon et al., 2012; [3(9)]Hackes et al., 1997; [2]Deutekom et al., 1991; Kelly, 1999.
Assessing food and nutritional intake	[1]Cohen et al., 2013; [3]Nichols et al., 2002; [2]Burghadrt and Devaney, 1993.
Estimating financial cost of food waste	[1]Cohen et al., 2013; [1]Buzby and Guthrie, 2002.
Monitoring menu performance	[2]Connors and Rozell, 2004.
Assessing causes of food waste in food service institutions	[2]Williams and Walton, 2011; Kelly, 1999.
Evaluating the effect of type of meal service on plate waste	[1]Yon et al., 2012[7]; [2(8)]Wilson et al., 2000; [3(9)]Hackes et al., 1997; Kelly, 1999[8]
Testing accuracy of food plate waste estimation methods [5]	Williamson et al., 2003.
Determining the effect of adding flavours to food (milk) [6]	[1]Yon et al., 2012.

[1]Study conducted in school
[2]Study conducted in hospital
[3]Study conducted in a retirement living centre
[4]Study conducted in a University
[5] Study compared digital photography method to weighed and visual estimation methods.
[6] Study examined the consumption of flavoured milk against normal milk
[7]Studied the effect of 'offer versus serve' meal service on quantity of milk consumption
[8]Assessed the effect of plated versus bulk meal service systems on food waste
[9]Compared three main meal service style-tray service, wait-staff service and family-style service and their effects on the quantity of food consumed and wasted.

The literature reveals two main techniques of assessing plate waste, namely: weight and visual estimation techniques (Buzby and Guthrie, 2002; Kelly, 1999). Weighing food plate waste has been cited as the most accurate way to measure both food intake (consumed food portions) and food waste (Williamson et al., 2003). Weight measurements can be carried out for individual consumers (individual weight method) or by accumulation of bulk plate wastes from different

consumers (aggregate weight method) (Buzby and Guthrie, 2002; Comstock et al., 1979). In both methods, plate waste is computed as a fraction or percentage of food that was left uneaten (Williams, and Walton, 2011).

Comstock et al. (1979) outlines the limitations of the individual weight method:

a) Low accuracy levels notably in cases where there is food spillage or trading of food items or portions among study participants. Food trading is especially common in school feeding programs (Baxter et al., 2001).
b) It is highly responsive to variations in the original food serving sizes. This may affect reliability and accuracy of findings.
c) Compared to visual estimation, the individual weight technique significantly interfere with daily cafeteria routines.
d) It is arguably the most time consuming and therefore most expensive method. In cases where big samples have to be used, this technique is almost impractical.

While resource intensive, the individual technique provides relatively more accurate and detailed information on plate waste (Comstock et al., 1979).

The aggregate weighing technique evaluates the total edible plate waste without separating the waste from individual consumers or food items (Williams and Walton, 2011). Buzby and Guthrie (2002) suggest the use of this technique when a gross estimate of the total food wasted as opposed to specific quantitative information of individual foodstuffs wasted or consumed is required. Therefore, the aggregate method is unsuitable for economic studies on food waste because such studies require detailed information on the type of foodstuffs that are actually wasted.

The visual estimation technique entails the use of a pre-designated scale to estimate, to an approximate value, the proportion of originally served food that is left uneaten (Kirks and Wolff, 1985). Typically, trained observers carry out the estimation by way of sight (Comstock et al., 1979). Williamson, et al. (2003) recommend the use of this method for food plate waste estimation in cafeterias or other public eating institutions.

Visual estimation has been used widely. Williamson et al. (2003) applied it to study nutrient intake and eating behaviours in a food service institution while Simmons-Morton et al. (1992) used it to validate two food intake assessment methods i.e. weighing and digital photography methods. The latter study found that direct visual estimation yields accurate results (of food portion sizes) just like weighing and digital photography methods.

Connors and Rozell (2004) provide a summary of the strengths of the visual estimation method:

a) It provides fairly accurate information on the extent of plate waste without requiring extra space to hold the soiled trays during analysis. This makes the method relatively simple and less costly as it does not involve handling of soiled trays.
b) It permits data gathering on actual consumer behaviour as opposed to data on intended consumer behaviour.
c) During analysis, there is no interaction between the observer and clients. This reduces chances of observer bias or errors while enforcing the method's universal precepts and precautions.

While the visual plate waste method can provide fairly adequate information on the food waste with minimal disruption of foodservice activities, Kirks et al. (1985) recommend exercising caution notably when dealing with aggregated food groups. The visual method does not allow analysis of the individual food types that form these food aggregates. The chances of getting incorrect results in these cases are therefore increased. However, Connors and Rozell (2004) argue that if the motive of a study is to only highlight the food items that consumers' waste most without providing further details about the foods, then the visual plate waste method suffices.

Digital photography makes use of technological advances to improve dietary assessments. According to Williamson (2003), digital photography operates like direct visual estimation. However, a digital video camera records the food consumption and plate waste instead of trained observers. The food photographs recorded in the camera are then transmitted onto a computer. Trained observers then estimate the amount of food wasted using the portion sizes as visible in the digital photographs. Weight of food items are recorded before and after meal consumption.

Williamson et al. (2002) contends that digital photography, like visual estimation, is suitable for studying food consumption patterns in food service institutions in which the quantities of food prepared and served are measurable. These include University dining facilities, nutrition centres for the elderly, and school feeding programmes.

Williamson et al. (2003) compared the accuracy of digital photography method to weighing and visual estimation. Using a sample of 60 meals made up of ten varying food portions picked from six dissimilar University cafeteria menus, they found that digital photography and direct visual estimation methods had a strong correlation with each other. Digital photography yielded comparable results with little under or overestimation compared to results obtained from weighing method.

Williamson et al. (2003) summarise the advantages of digital photography:

a) Permits acquisition of robust data rapidly and instantly within the dining environment. This makes the method convenient for both study participants and investigators.
b) Allows comprehensive evaluation of food waste since the photographs of food wasted can be evaluated at a later time as opposed to immediately in the dining environment.
c) Eliminates investigators' bias who sometimes estimate the amount of food waste without examining clients' plates. Investigators sometimes tend to have pre-conceived notions about clients' regular food consumption and wastage.
d) Besides taking the actual picture, digital photography allows capturing of both date and time of the day. This information is crucial when adjusting clients portion sizes depending on the time of the day. Even so, constant disruption of the eating environment or hurried data collection may make the results obtained through digital photography unreliable

2.6. Food waste in food service institutions

2.6.1. Introduction

Consumers depict two main types of practices with respect to food consumption: food consumption within the home and consumption away from home. The latter involves food provided by food service institutions (FSI). The food service sector is also commonly referred to as the hospitality sector.

According to the Nordic Council of Ministers (2012), the hospitality sector consists of the profit sector and the cost sector (not working for profit). The profit sector prepares and serves food at profit and includes hotels and guest houses, restaurants and cafes, canteens, catering individuals/companies, supermarkets and other food stores, pubs and bars (WRAP, 2011). The cost sector comprises businesses whose main purpose is not to provide hospitality services. Examples include catering and accommodation services within the premises of schools, universities, hospitals, nursing homes, prisons, military facilities, and self-operated canteens within companies (Schneider, 2013; WRAP, 2011). Food consumption out of home is on the rise. In the US alone, the proportion of total spending on food out of home grew from 25.9 percent in 1970 to 43.1 percent in 2012 (USDA, 2013).

The amount of food waste generated from the hospitality sector is too big to be ignored (Bond et al., 2013, USDA, 2011, Engström and Carlsson-Kanyama, 2004). In fact, the British Hospitality Association (2014) argues that food waste is the greatest challenge to the prosperity of the food service industry. The absence of food waste monitoring and management practices in this industry has seen operational costs rise steeply in the last few years. Parfitt et al. (2010) established that consumers, food service institutions and retailers are the three main actors in the food supply chain with the greatest potential for the reduction of food losses and wastes. While much focus of food waste studies has been given to households and retailers, minimal attention has been given to the hospitality sector. Considering that the progress of food service institutions - like any other business - depends on cost efficiency and financial viability (Whitehair et al., 2013), strategies to reduce quantities of food waste must continually be engrained in their operations.

Food waste in service institutions can be broadly categorised as:

(a) Kitchen waste – which includes wastes that occur during food storage, ingredient preparation, cooking, and serving (Engstrom and Carlsson-Kanyama, 2004). Elsewhere, kitchen wastes are referred to as pre-consumer waste (LeanPath, 2012). Kitchen waste also includes foods prepared but never served and eventually discarded i.e. left overs (Youngs et al. 1983).

(b) Plate waste – which is food that is served but left uneaten and discarded (Connors and Rozell, 2004). LeanPath (2012) refers to plate waste as post-consumer food waste or 'table scraps'.

The amount of food plate waste generated from a food service institution may be represented in various ways. Most studies present by way of weight i.e. by expressing the remaining uneaten food portion as a percentage of the initially served amount of food (Williams and Walton, 2011). Some studies express waste as a percentage of the energy value or protein content of the meal (Wilson et al., 2000; Youngs et al., 1983). This is common in hospitals and

school settings where researchers seek to establish the amount of nutrients or energy that patients or students consume respectively. However, this method has been shown to be complex and requires detailed information about every food item wasted. Therefore, careful analysis is required otherwise the results may be inaccurate. Other authors (Cohen et al., 2013; Barton et al., 2000; Al-shoshan, 1992) have assigned monetary values to the amount of waste.

Of both types of food waste generated from foodservice, plate waste is greatest. A study by Engström and Carlsson-Kanyama (2004) established that while food wastage during handling, storage, preparation and serving have substantially declined (based on historical trends), plate waste is steadily increasing. This makes it the single largest contributor to overall food waste in foodservice. This finding is supported by that of Williams and Walton (2011) who summarised 32 food plate waste studies from 29 countries over a period of 50 years. They reported that the extent of food plate waste remains high with no trends of decrease over time.

Even so, different figures of food plate waste quantities exist in the literature. Apparently, the quantity wasted is contingent on the kind of food service institution. While in some institutions the figure is as low as 6 percent of the initial amount of food served, in others it is up to 65 percent (Williams and Walton, 2011). By and large, greatest quantity of food plate waste is generated from hospitals compared to other food service institutions (Williams and Walton, 2011; Kelly, 1999). A summary of the findings from selected key studies on plate waste in food service institutions is presented in Table 2.3, with methodologies including weighing, inferential and visual estimation. These studies show that amount of food waste varies considerably, with one study of four restaurants and five hotels in the UK (Young et al., 1983) reporting 3-42% and 20-38% food waste, respectively.

Table 2.3 Selected plate waste studies in food service institutions

Plate waste study	Food service institution	Sample	Method	Unit of expression	Results
Platt et al, 1963	152 hospitals in the UK	1 ward from each hospital (male and female)	Weighing	Wet weight basis	10±0.4 (Percent of food served that is wasted)
Youngs et al., 1983	5 Hotels, 4 restaurants in the UK	Hotels visited between 6 and 21 days	Weighing	Energy content basis	Percent of food served that is wasted: 20-38 (Hotels) 3-42 (Restaurants)
Frakes, 1986	1 University hospital in the USA	Examined 611 meals	Weighing	Wet weight basis	21.3 (percent weight of food served that is wasted)
Collison and Colwill, 1987	8 licensed restaurants, 2 store restaurants, and 11 public houses in the UK	-	Weighing	Energy content basis	Percent of food served that is wasted: 18 (licensed restaurants) 19 (store restaurants) 10 (public houses)
Kantor et al., 1994	USA (Nationwide)	Consumers Food service	Inferential	Weight	26 percent (of total edible food supplies)
Al-shoshan, 1992	18 hospitals in Saudi Arabia	554 patients (male and female)	Weighing	Wet weight basis	28.9 percent (weight of food served that is wasted)
Burghardt and Devaney, 1993	Countrywide USA		Weighing	Wet weight basis	12 percent (of food calories served)
Kowanko et al., 2001	1 Hospital in Australia	585 meals (male and female)	Visual estimation	Energy content and protein content basis	42.9 percent (of energy content served) 30.1 percent (of protein content served)
Nichols et al., 2002	1 community retirement living center in the USA	60 plates	Weighing	Wet weight basis	20 percent (weight of food served that is wasted)
Dupertuis et al., 2003	1 hospital in Switzerland	1416 patients (male and female)	Visual estimation	Energy content and protein content basis	23.4 percent (of initial energy content served). 26.4 percent (of initial protein content served)
Engstrom and Carlsson-Kanyama, 2004	2 schools and 2 restaurants in Sweden	850–950 and 250-600 meals portions in schools and restaurants respectively	Weighing	Wet weight basis	20 percent (weight of food served that is wasted)
Hiesmayr et al., 2009	256 hospitals in 25 European countries	16,290 (male and female)	Visual estimation	Wet weight basis	18 percent (weight of food served that is wasted)

2.6.2. Plate waste in dining facilities

Causes of plate waste

According to WRAP (2011), the causes of food waste in food service institutions can be broadly classified into three main categories: operational, situational and behavioural. Operational causes include the food service institutions' policies and practices that dictate menus, food preparation, serving styles, flexibility of portion sizes etc.; and the operations systems, for example, the availability of a meal booking system that records and communicates the total number of consumers expected to eat specified meals or food items on given days.

'Operational' causes are food and menu issues which concern practices applied during food preparation and presentation. According to Kelly (2009), the amount of food waste is tied closely to the type of food menu and catering service being used. Equally, inappropriate portion sizes have been shown to increase plate waste (Collison and Colwill, 1986). The last three decades has seen food portions served in food service institutions increase tremendously (Gunders, 2012; Marchiori et al., 2012). Excessive food portions are responsible for uneaten food scraps.

Additionally, inappropriate food appearance, poor food quality (e.g. over/under spicing or cooking), and incorrect temperatures reduces food consumption (Huang and Shanklin, 2008; Banks and Collison, 1981; Hong and Kirk, 1995). Likewise, limited menu choices with limited food types to choose from may cause menu fatigue, which in turn lowers consumers' eating enthusiasm (Deutekom et al., 1991). However, extensive menu choices may also reduce the quality of inventory management since broad menus need constant availability of more inventories (Gunders, 2012). Poor inventory management increases the amount of food waste generated from a food service institution.

'Catering' or 'food service' issues that promote food waste are numerous. They include physical issues such as inappropriate packaging which makes food difficult to open and consume. Similarly, insufficient information on the types of foods that are available may increase the chances of clients ordering the food they do not know. Unfamiliarity with food has been shown to increase plate waste (Kelly, 1999). Equally, negative attitude of the catering staff, delivery of incorrect food items or incorrect food assemblage reduces the chances that clients will finish their meals (Williams and Walton, 2011; NHSE Hospitality, 2005).

While not responsible (in most cases) for food waste in University dining facilities, clinical issues cause food plate waste around hospital settings. They include dental problems, difficulties in swallowing and the inability to recognise food significantly lowers food consumption which result from physical and psychological changes in patients as a result of disease (Williams and Walton, 2011; Walton et al., 2006; Deutekom et al., 1991).

Situational causes of food waste refer to the wider environmental factors that influence food service institutions' operations besides food-specific issues. Therefore, this category includes infrastructure constraints that prevent the minimisation of food waste.

The eating environment has constantly been shown to dictate food consumption and food waste (Huls, 1997). Factors such as inappropriate meal times, excessive noise, bad room odour, insufficient eating time, constant interruptions during eating, among others, significantly lower food consumption quantities (Williams and Walton, 2011; Deutekom et al., 1991).

Along with environmental factors, availability of substitute foods from competing food sources is responsible for plate wastes within learning environments (WRAP, 2011b; Bark, 1998). Usually, within school compounds are located shops that sell snacks and other foods to students. Buying and eating food from these shops reduces negatively the quantity of food that students' may eat from the school's main dining facility.

'Behavioural' comprises consumers' behaviours and attitudes towards food. Typically, behaviours are responsible for fluctuations in demand for food at the point of sale. For example, a food service institution may prepare but never serve all the food if consumers have a negative attitude towards the food or the catering staff. Still, weather changes significantly affects

consumers' tastes and preferences. Although the food service industry can work to modify consumers' behaviours, Kantor et al. (1994) contend that most behavioural causes to food wastes are beyond the control of food service institutions.

2.7. Practical measures for reducing food plate waste in universities' dining facilities

Essentially, decreased levels of plate waste is an indication that consumers' food and nutritional needs are being met. In reality, there is no single solution that can sufficiently solve the intractable and intricate problem of plate waste. Therefore, a multifaceted approach that involves sequential trial and appraisal of potentially effective approaches is necessary (Williams and Walton, 2011). From the literature, the methods discussed in the section that follow have been applied successfully to reduce food waste in Universities' dining facilities.

2.7.1. Implementing 'offer versus serve' food serving option

Offer versus serve allows students to select only the foods they want to consume. Instituting self-service bars enables tailoring of food portions sizes according to individual students' appetites and energy needs (Buzby and Guthrie, 2002). Ultimately, students choose only the foods they want and thereby reduce the quantities of plate waste.

While offer versus serve significantly reduces food waste, it does not necessarily improve nutritional intake of foods. On the contrary, allowing self-service may hinder provision of nutritionally balanced meals. This is because students tend to select only the foods that they like, irrespective of their nutritional content. A way around this may be implementation of a nutrient standard meal planning system which stipulates the minimum food quantities (e.g. entrée or fruits and vegetables) that students should choose from and a maximum number of food types that they may decline during meal serving (Buzby and Guthrie, 2002).

2.7.2. Convenient scheduling

Meal scheduling has an impact on food consumption and plate waste (Bergman et al., 2004). Getlinger et al. (1996) found a reduction in plate waste by 10.6 percent when recess was scheduled before lunch instead of after lunch. Bergman et al. (2004) also observed that students in schools having recess before lunch consumed more food calories than in schools in which recess was scheduled after lunch. Inappropriate scheduling of routine school programmes may interfere with meal consumption, for example, constraints that result in meals being served when students are not hungry (Bergman et al., 2004).

2.7.3. Improving food quality and acceptability

Improving food quality and acceptability increases food consumption while minimising plate waste. In a report on strategies to reduce food plate waste in schools, Buzby and Guthrie (2002) suggested the following:

(a) Local sourcing of fresh produce. This potentially improves the consumption of most foods including salads and vegetables, which are typically the most wasted food items. Essentially, local sourcing has numerous advantages:

(1) It provides customers with fresh produce while simultaneously reducing the risk associated with food spoilage as a result of travelling long distances.

(2) By reducing the distance food travels, local sourcing reduces the quantities of energy used during storage and transportation. This also means reduced transportation costs incurred by the food service institution. In some cases local sourcing eliminates the need for packaging. This enables financial savings by the local producers and suppliers.

(3) Finally, local sourcing stimulates growth of local economies. This may enhance the reputation of the food service institution in question (Gunders, 2012).

(b) Use of commercial food catering companies and their products. It is believed that subcontracting can improve the quality and nutritional value of meals while simultaneously creating significant financial savings. Likewise, use of branded food items can decrease plate waste by increasing food acceptability (United States Government Accounting Office (USGAO), 1996).

(c) Strengthening student input, for example by way of student advisory groups. Involving students in menu planning may increase food acceptability Hartwell et al. (2006). Through students' forums, dining facilities can discuss alternatives foods they can provide considering the population they serve and budgetary constraints.

(d) Empowering students by providing nutrition education is central to enhanced food consumption and low plate waste. According to NHSE Hospitality (2005) nutrition education entails furnishing consumers with information on the menu options and also explaining the dietary contents of all the foodstuffs being served. Likewise, clients can also be provided with food samples for tasting prior to ordering. This increases familiarity with the foods being served and hence limits the chances of wastes. Liquori et al. (1998) established that educating students by involving them in meal preparation and tasting increased meals consumption and reduced plate waste. This is because students obtained prior knowledge of the foods they will be served.

2.7.4. Reducing the size of eating bowls

Customising food portion sizes to match students' energy requirements and appetites is key to reducing food plate waste. This can be achieved through regulating the sizes of eating bowls. Wansink et al. (2013) assessed the impact of bowl size on the amount of food that students request, consume and waste. They established that students request and waste more cereal when served in large bowl (16 ounces) compared to a small bowl (8 ounces). While children served in larger bowls wasted 92.2 grams, those with smaller bowls wasted only 25.4 grams. Therefore, reducing meal bowl or plate sizes can reduce the amount of plate waste generated.

2.7.5.   Engaging students in food waste minimisation strategies

According to Engström and Carlsson-Kanyama (2004), involving students in food plate waste minimisation campaigns is central to reducing waste. In dining halls, students can be engaged in regular food audits by inviting them to weigh, display results and chart plate waste minimisation strategies. This raises awareness and understanding among students and consequently spurs change from wasteful and bad food consumption habits.

Equally, engaging students in food waste reduction discussions can stimulate positive change. In view that food waste discussions may not be readily incorporated into school teaching curriculum, teachers should spare some time and talk to students about the benefits of and how to get involved in food waste reduction. In a study to compare waste trends in schools, Engström and Carlsson-Kanyama (2004) reported up to 35 percent decrease in the quantity of plate waste in schools where teachers discussed food waste in their classes.

2.7.6. Using appropriate food pricing system

A pricing system that charges food based on weight is preferable. Paying for food by weight eliminates the popular 'all-you-can-eat' meal serving system. According to Engström and Carlsson-Kanyama (2004), this is a practical approach to limiting food plate waste because it makes clients exercise more care while selecting the quantities of food: people will always avoid selecting and paying for food that they do not end up eating.

2.7.7. Employing appropriate food menus to reduce plate waste

According to Williams (2009), two types of food menus predominantly exist in food service institutions. On the one side of this divide are a la carte menus. These menus typically offer a wide range of food choices but these choices remain unaltered. Put differently, institutions using a la carte menus serve the same types of food every day. On the other side of the divide is a cycle menu in which a cycle of a series of daily or weekly menus is used. This menu cycle is then repeated after a period of time. Sometimes the menu cycle is repeated according to the weather pattern e.g. one cycle for winter and a different one for summer. Cycle menus are frequently used in school settings, in healthcare, and prisons because unlike a la carte menus, they offer variety of food choices. Generally, a la carte menus are thought to be easy to use because they enable "predictability for ordering, budgeting and production" (Williams, 2009:14).

An important component that works synergistically with food menus to cut plate waste is a meal booking system. This information system enables clients to order meals in advance while providing accurate and timely information to the catering staff on the types and quantities of foods that should be prepared. In this manner, the system reduces over-reliance on past food consumption trends to make future predictions - a phenomenon that has consistently been associated with high plate waste (NHSE Hospitality, 2005). Additionally, a meal booking system is a valuable tool during food waste monitoring and auditing as it provides a benchmark for establishing the number of meals that were ordered and the number of portions that were supplied. In this way, a meal booking system functions as a guide to future food provision while simultaneously facilitating the traceability of unpopular dishes for adjustments (NHSE Hospitality, 2005).

The role of a good menu in decreasing plate waste cannot be trivialised. An effective menu not only minimises food waste, but also, optimises clients' nutrition, supports positive perceptions, and institutes a foundation for achieving financial goals and intentions (Connors and Rozell, 2004). For example, a diverse menu with increased food choices enables clients to order and eat the foods they like. Although this does not guarantee reduction of plate waste, it is perceived that consumers eat up foods that they like compared to those that they don't like, thereby reducing plate waste (Sonnino and McWilliam, 2011). According to Díaz and García (2013), most food service institutions focus principally on factors that enhance food quality or speed-

up food delivery to increase nutrient consumption and reduce food waste; few institutions adapt their menus and food choices to suit clients' perception and satisfaction.

However, instituting a good menu is not enough; evaluation of the food consumed is also crucial. Besides offering popular food items, an assessment of the menu to determine if the food items offered are eaten is crucial. Hence, menus should constantly and systematically be appraised to determine their relevance and effectiveness and provide objective information for decision-making (Connors and Rozell, 2004). Performing a plate waste study can help to establish the suitability of every food item on the menu.

Menus can be displayed on paper, boards, lit-up signs, posters outside the institution or digital screens that enable the display of food items and prices as moving images or animated effects. Food service institutions that have an online food ordering system can have online menus incorporated into such systems. Pictorial menus make it easy for clients to make meal choices (NHSE Hospitality, 2005).

Where applicable, menus help waiters from taking wrong orders. Likewise, menus help solve the problem of language barriers between clients and waiters. Equally, clients are able to make compliments or complaints about the food items or meals thay eat if they know or can see them in the menus (NHSE Hospitality, 2005).

2.7.8. Appropriate meal service system

Meal service systems also have a direct impact on clients' food and nutritional intake and hence plate waste. A study by Wilson et al. (2000) compared the effects of plated versus bulk meal service systems on clients' food consumption. While the food served on both systems had similar nutrient content, a plated meal system generated more plate waste than a bulk system. These findings agree with those of Kelly (1999). He conducted a food waste audit in a UK Hospital and found out that food wastage (on average) from the bulk system was 50.5 percent compared to 61.6 percent for the plated system. Another study by Hackes et al. (1997) compared the effect of health care tray service, wait-staff service, and family style service systems on the quantity of service food waste (SFW) in a continuing-care retirement community centre. In tray service, catering staff usually serve meals to clients (usually confined in rooms) and return to collect the trays while in the wait-staff service, catering attendents stay to monitor clients food consumption and and to respond to their additional requests. The family style is a group dining, usually around one or more dining tables depending on the number of clients (Puckett, 2004). The study found that the health care tray service generated the highest quantity of waste-both by weight and volume-compared to wait-staff service and family style service.

Wilson et al. (2000) distinguishes three types of meal service systems: centrally plated, bulk method and cafeteria style. In the centrally plated system, clients order from the catering department, meals are plated-up and transported to the dining rooms where they are served directly to the clients. A plated system permits catering staff to respond immediately and locally to clients' requirements as regards food choices and portions. Additionally, it allows serving food in small portions firstly followed by second helpings (Kelly, 1999). This encourages food intake while reducing food plate waste. In the bulk method, caterers approximate the total amount of food required by clients based on the number who order meals. Meals are then packed in containers and transported to clients for serving. This system, unlike the plated one,

permits clients to change their meal choices at point of service. While this may reduce plate waste, because clients serve the food they like, it greatly reduces the efficiency of the catering staff. In extreme cases, it literally means taking new orders at the point of service. Furthermore, when clients change their minds at the point of service, the catering department is forced to prepare extra amounts of food in anticipation that clients can consume them in case they change their mind. This undeniably greatly increases the quantity of food that is prepared but not served (Williams, 2009).

The third meal service system is the cafeteria style commonly used at workplace canteens, Universities and certain schools, various military settings, prisons and nursing homes. Specific meals from the insitution's menu are served either by clients or by catering staff. This allows clients to make food choices immediately before food consumption (Williams, 2009). Among other advantages, Williams and Walton (2011) argue that by allowing customers to choose foods just before dining time, plate waste is reduced. Portion sizes and meal ingredients (e.g. sauces) can continually be adjusted to suit clients' preferences. Likewise, the cafeteria style is very cost-effective for the food service institution as it requires relatively few staff to serve, deliver and clear meal trays and does not require any exceptional apparatus to keep optimum meal temperatures between points of service and consumption (Williams, 2009).

However, the number of meal choices available in a cafeteria system is restricted to those that can be put on display at the point of service. Moreover, since food is not made to order, high quantities of food may be prepared but not served. Food quality may deteriorate if food is held for considerably long periods of time before service (Williams, 2009). This may reduce food palatability and hence acceptability among clients. Most importantly, cafeteria style is only applicable in a few food service institutions. Essentially, in an extreme case, cafeteria style means preparing different meals for different groups with special dietary requirements. This may not be logistically possible or economically viable in institutions that deal with huge numbers of clients.

According to NHSE Hospitality (2005), the public perception of the meal service system of a food service institution is crucial in attempts to lower food plate waste. A positive attitude by clients increases their expectations of the food they are served and they are more likely to finish the meals they get served. Therefore, ongoing attempts should be made to address and improve the public perception of a foodservice institution and its catering system.

2.7.9. Staff training

While food service managers can individually reduce food waste, each staff member has a unique role to play. Since individual staff members are involved in day-to-day handling of foodstuffs, for example food purchasing, storage, preparation, disposal and general organisation, their integration into planning and implementation of food waste minimisation efforts is crucial. As Peregrin (2011:1293) argues, staff members are central in every successful and sustainable foodservice operation because they are the ones "who make things happen". As such, it is a real asset to train them along more conservative and sustainable ways.

Training should involve every staff member as reducing plate waste is a complex process that requires a systemic approach. Moreover, Engström and Carlsson-Kanyama (2004) maintain that creative and effective plate waste reduction solutions can be designed and implemented through collaboration between staff members and diners.

Training should equip the staff members with sound methods on food preparation, storage, serving (especially as regards portion sizes) and waste tracking. Staff members should be encouraged to provide suggestions that can bring change. Peregrin (2011) notes that the most essential part of staff training entails explanation of outcomes. Doing this is an effective way to motivate staff members since they can see and appreciate changes or progress as they occur. Acknowledging and providing incentives to staff members who show greater commitment or discover new and effective strategies of reducing waste can help significantly induce positive change on inactive staff members. Staff should be informed of every financial saving or improvement to motivate them further, which means even further savings.

2.7.10. Food plate waste auditing

Persistent plate waste within food service institutions has been attributed to absence of regular food waste auditing. Gunders argues that "what gets measured gets managed" (2012:15). LeanPath (2012) defines food waste auditing as the practice of analysing waste streams to characterise-in types and quantities-various food items wasted to aid planning of appropriate waste management. Rationally, reducing plate waste requires initial and proper understanding of the magnitude of food waste as a problem. Thus, Williams and Walton (2011) contend that the most fundamental approach to minimising food wastage entails close and regular monitoring and auditing of the wastes generated. Only then can appropriate measures to curb food waste be decided on and executed.

According to Gunders (2012) by conducting detailed food waste audits and setting minimisation targets, businesses can greatly increase the efficiency of their operations. This is because comprehensive food waste audits sets up useful reference points both for assessing goals and specifying opportunities for creating savings.

According to Nichols et al. (2002) food waste auditing also helps in menu planning. It can be used to determine which dishes customers frequently return to the kitchen or leave uneaten. Using this information, food service managers can appropriately rework menus to improve customer satisfaction and reduce plate waste.

Along with reducing overall food wastage, auditing also helps in improving food recovery and redistribution. As Kantor et al. (1997) points out, understanding where and how much food is lost is important in increasing efficiency of food recovery efforts.

Food waste auditing can be done by the food service institution's staff or by institutions that specialise in waste auditing. Alternatively, automated food waste tracking systems can also be used. While irregular food waste audits can be of help, Díaz and García (2013) suggest that food waste auditing should be part of every catering establishment.

2.7.11. Consumer education

While many of the strategies already suggested may go some way to reducing plate waste, putting measures that prevent food waste among consumers and in foodservice in the first place should be the priority (Kantor et al., 1994). Griffin et al. (2009) proposes changing consumer behaviour through education. Similarly, Kantor et al. (1997) maintains that education programmes, if applied appropriately and effectively, can minimise and prevent food waste altogether. For example, furnishing consumers with the information about the relationships between their behaviours and the environmental consequences of such behaviours can

stimulate positive change of behavior. Consumer education on food waste creates and increases ecological awareness (Paul and Rana, 2012) .

Ecological awareness has been described as a complex phenomenon that requires an understanding of three crucial environmental dimensions namely; environmental knowledge, environmental attitudes and environmental values. Willingness to act in line with these dimensions and the actual action are equally important. Good knowledge on ecological awareness enables understanding of environmental problems which then influences human beings behaviours and action (Paul and Rana, 2012).

Clearly, change in consumers behaviour is crucial in the fight against food waste. Even with this fact, Whitehair et al. (2013) observes that research on food waste in foodservice operations has mainly concentrated on assessment of food waste quantities, components and programme implementation with little emphasis on altering individuals' behaviour. Available evidence shows that performing educative campaigns and providing feedback on such campaigns can positively sway individuals' behaviours from wasteful to more sustainable (Petersen et al., 2007).

Whitehair et al. (2013) assessed the impacts of printed messages in a University dining hall during a six week period. By observing a 15 percent reduction in mean food waste after executing educative campaigns, they concluded that written messages discourage plate waste in dining halls. They also established that while the majority of students express positive beliefs regarding sustainability, they rarely exercise those beliefs. Thus, it was uncovered that by simply exposing students to simple prompt-type stimulative messages, augmented awareness of food waste and change in behaviour is triggered. Unmistakably, education and communication are central in the quest for client behaviour change.

Another way of providing education to consumers, especially students in dining facilities, is via point of selection nutrition information. It is hypothesised that this information influences consumers' food choices and purchases, especially as regards food energy content. According to Peterson et al. (2010), this is a social marketing strategy which, unlike traditional marketing that is intended to fulfil consumer wants and needs, aims at changing consumers' behaviors or attitudes, especially their judgements, morals, beliefs, actions, or values.

Freedman (2011) assessed a point of selection nutrition information intervention in a University dining hall. He placed real photographs of larger food portions next to smaller portions in an all-you-can-eat dining facility and provided quantitative nutritional information (fat grams and total calories) for each portion. He also placed two slogans at various points in the dining facility: "'Portion Size Matters' and 'A Small Change Makes a BIG Difference'" Freedman (2011:89). He found 17 percent of the students switched to smaller portions after the intervention. This study by Freedman (2011) shows that point of selection nutrition information can influence what students purchase to consume and in what quantities; therefore, it can be used to discourage consumers from serving huge quantities of food that they cannot eat and end up discarding. Although Freedman (2011) was not able to ascertain the individual effects of either the visual cues (the real pictures) or the quantitative information, it showed that a combination of the two is likely to have the greatest impact on students' choices. While the main aim of this study was to evaluate measures to reduce food consumption as opposed to plate waste minimisation, it shows that tailoring messages to suit people's self interests can

effectively reduce food waste compared to goal such as sustainability which is not easily comprehensible.

'*Love food hate waste*' is a campaign that promotes prudent use of food and other natural resources in the UK and is a good example of the impact of education food waste. WRAP (2013) claims that following a '*Love food hate waste*' campaign in West London - a local authority with approximately 600,000 households - avoidable food waste decreased by 14 percent in just under six months. If figures from this research are scaled to every household in this waste authority, 20,000 tonnes of carbon dioxide emissions could be prevented. A further Euros 1.3 million worth of disposal costs would be saved.

Campaigns such as this are not only replicable but also possible in virtually every food service envronment. Whitehair et al. (2013) suggest that campaign educational messages need not to be too detailed or research based. Keeping them simple and without too much information and data makes them easy to read and comprehend quickly. Alternatively, behaviour change can be increased by formatting education "messages into statements focused more on social issues such as hungry children or family meals" (Whitehair et al. 2013:68). Social statements like 'the amount of food you waste in a week is enough to feed a family of four in a day' appear more factual and weighty and can stimulate a greater change. Even so, considerations should be made to ensure that appropriate terminology and message formatting is done depending on the target population.

2.7.12. Appropriate communication

While people might easily access information on food waste and its consequences, it is not guaranteed that they will understand such information and apply it in their daily lifestyles. Sufficient, consistent and effectively targeted communication is crucial to successful plate waste minimisation strategies (Zhang et al., 2011). Kelly et al. (2006) argue that knowledge gaps among different actors within the food service community limits the chances of success of reduction strategies. For example, in dining facilities, consumer choice of large food portions that increase plate waste has been attributed to lack of information that smaller food portions can be availed on clients' request (Kelly, 1999).

To enhance communication within dining environments, the Environmental Protection Agency-EPA (2014b) suggests posting informational signs-with the inteneded messages-at the food service venues. This facilitates consumers' choice (Williams and Walton, 2011). Likewise, catering staff members should be trained not only on nutrition and food safety aspects but also on effective communication, customer care and team working skills (NHSE Hospitality, 2005). This can improve their attitudes and receptiveness towards clients. Receptiveness to clients is central to customers' satisfaction and dining pleasure. Equally, implementation of waste minimisation strategies must be accompanied by suitable publicity and promotion, both of which require effective communication. Put succinctly, a well developed and sustained communication and participation from the whole foodservice fraternity is key to any plate waste minimisation strategy (Zhang et al., 2011).

2.8. Strategies for creating value from food plate waste

2.8.1. Introduction

In reality, due to its complexity and intricacy, complete elimination of food waste in foodservice is not achievable. Food is simply too precious to be wasted. Stuart argues that "even when unfit for human consumption, food waste is a valuable resource that can be used for animal feed, power production and fertile compost" (2009:1). All of these options are preferable to sending food waste to the landfill, with its associated negative impacts mentioned in section 2.4.

In an attempt to quantify food waste generated in various stages of food supply chain, Griffin et al. (2009) analysed an entire US community food system. They established that little is being done to create value from food waste: only 25 percent of total food waste is recovered by means of composting, 3 percent was donated while the rest, 72 percent, is landfilled. This shows that majority of consumers prefer discarding food waste to using them to create products of value.

Strategies aiming at addressing food wastes should consider prevention as the fundamental priority (RSIS, 2013). The US EPA (2014) provides a hierarchy for the handling of food waste (figure 2.1). The following section discusses food waste recovery, industrial use of food waste and composting as methods to create value from food destined for waste.

Figure 2.1 Alternatives to handling food losses and wastes

(Source: Food Waste Reduction Alliance (FWRA) 2014:1).

2.8.2. Food recovery and distribution

Gunders (2012) conceptualises food recovery as the act of garnering excess or edible food and distributing it to those who need it. The process entails gathering perishable, non-perishable, and already cooked food items from the various actors along the food supply chain. Incidences of food over preparation and leftovers within food service institutions make them good targets for recovery efforts (Engström and Carlsson-Kanyama, 2004). Recovered food is then handed over to food donation systems, for example food banks which in turn redistribute it to people with limited access to food (RSIS, 2013; Griffin et al., 2009). Even in affluent countries such as the US, poverty and hunger are realities (EPA, 2014). As such, food collection and redistribution can play a significant role in improving food security (Griffin et al., 2009; Kantor et al., 1997).

Along with improving food security, food recovery and redistribution has several benefits. It enables the provision of additional quantities of food to the hungry. This means increased variety and nutrients in their diets. For the food collecting and redistributing organisations, food donations means reduced expenditure on food purchases (Kantor et al., 1997). Usually, in the absence of food donations, food organisations buy food to distribute to the needy so donations frees up money for spending on equally important services such as provision of shelter.

Economically, food service institutions that donate food save significant amounts of money associated with waste removal. This is especially true in countries such as the US where a number of waste haulers charge their clients less if they separate food waste from the rest of the trash (EPA, 2014). Additionally, donating wholesome and edible food may provide tax benefits (or tax exemption) to food banks, food rescue organisations, and the food donating businesses (EPA, 2014; USDA, 2014). This ultimately means more money at their disposal to use on other activities. Even in areas where tax benefits are not provided, foodservice institutions and other donating organisations can benefit from the goodwill associated with providing food to the less fortunate.

Food recovery can benefit the whole community, not only the less fortunate. Besides discouraging unnecessary wastage of quality food, food recovery and redistribution can create stronger community ties and integration (USDA, 2014). Since recovery efforts rely on coordination between various individuals including community volunteers, farmers, retailers, and food banks, which can make the local food system stronger.

However, food recovery and redistribution is a contentious issue. Firstly, aspects such as food hygiene or quality and the possible health consequences of consuming recovered food have hampered recovery efforts (RSIS, 2013; Engström and Carlsson-Kanyama, 2004). Consequently, systems and processes that ensure that the value and safety of edible food waste are retained are key to food recovery, donation and redistribution. Donating organisations argue that governments' regulations as concerns reuse of food are typically too stringent. In most cases, there are legal implications involved, for example, in the event of negative health consequences after consuming donated food. RSIS (2013) observes that this prohibits collection and redistribution of potentially safe food. However, some countries like the US have worked around this challenge: they passed the 'Bill Emerson Good Samaritan Food Donation Act' that protects potential food donors from any legal liabilities that may result if people fall ill as a result of eating donated foods (Kantor et al. 1997).

Recovery, conversion and redistribution of 'lost' food into food fit for human consumption can be costly and sometimes formidable (Gunders, 2012). Locating food donors, securing paid labour or volunteers, training workers on safety measures during food handling, and securing funds for establishing infrastructure for storage, packaging and transporting of the donated foods, all require significant commitment from both public and private sectors (Kantor et al., 1997).

Considering the full environmental, social and economic costs of wasted food, the gains from food recovery and donation outweigh the costs. Accordingly, policies and measures that create a favourable environment and provide incentives for food donations by food service insitutions are crucial. Likewise, incentives such as awarding bonuses to food service establishments or

proving some measure of reimbursement for the cost of the donated food may work (Griffin et al., 2009).

2.8.3. Using food waste for industrial purposes

Through industrial processes, products of value can be created from food leftovers and plate waste. According to Kantor et al. (1997), technological advances that allow food and food-by-products processing and development have great potential to reducing food wastage. Industrial technology permits conversion of wasted food into raw materials and other products with significant economic value. These products include animal feeds, compost manure, biodiesel (derived from animal fats and vegetable oils), adhesives and solvents (stemmed from citrus oils) to name a few (RSIS, 2013).

Biogas has multiple end-use applications depending on the scale of production. Common uses include in heating, lighting, cooking and powering machines. Biogas production has significant environmental benefits; it reduces greenhouse gas emissions, promotes soil nutrient recovery and recycling, and decreases level of harmful soil pathogens (American Biogas Council, 2014). Animal feeds can be used to supplement grain feeds and reduce costs for farmers. Undoubtedly, this means lower meat production costs and a consequential reduction in retail consumer prices.

2.8.4. Food waste composting

Composting is another relatively easy and practical way of creating value from food waste. Composting reduces the quantity of food waste while simultaneously turning it into compost - a safe, stabilised humus that can be used in gardening or growing crops (Mehta, et al, 2014; EPA, 2012). Therefore, composting is an economic way of reducing greenhouse gas emissions while simultaneously recycling soil nutrients. Composts can be used in addition to or in place of chemical fertilisers to revitalise soil, which can reduce farmers' expenses (RSIS, 2013).

Furthermore, composts act as biological suppressers of soil-borne plant pathogens notably fungi. Thus, composts are an alternative to chemical control of soil pathogens. While the use of chemicals is the most efficient method to control pathogens, chemicals have been associated with atmospheric pollution and evolution of chemical resistant pathogens (Mehta, et al, 2014).

Vermicomposting entails recycling organic materials like grass, leaves or uncooked food waste by way of red wiggler worms. Earthworms can break down waste and reduce its initial volume by 30–50 percent. Vermicomposting creates soil compounds and mixtures that are valuable for plant growth (Babich and Smith, 2010).

Anaerobic digestion, a variant of traditional composting, permits generation and capture of methane for energy usage. This energy can be compressed into natural gas and used to fuel trucks, drive boilers or turbines during electricity generation (FWRA, 2014). Thus, anaerobic digestion is considered a renewable energy source because the produced methane can replace fossil fuels, which have detrimental environmental impacts (American Biogas Association, 2014).

Bokashi technology, dissimilar from conventional composting, uses a special group of microorganisms, commonly referred to as effective microorganisms, to break down organic matter through anaerobic fermentation. The final fermented product is then converted into compost through vermicomposting or buried into soil (conventional composting). The Bokashi

process is carried out in a closed system and is odour free. Thus, it is convenient for most locations including urban and business settings (Barnes and Burt, 2009).

The greatest advantage of Bokashi technology is that, unlike conventional composting methods, it can ferment fats, meat and dairy products (Barnes and Burt, 2009). This makes it convenient since it does not require additional separation of food waste. Also, it is advantageous for the environment since all food waste can be treated in one occasion. This in turn enables treatment of problematic wastes such as bones as opposed to separating or throwing them away.

Composting has additional benefits in communities where it is practiced. It can play a central role in raising consciousness about food waste and its socio-economic and ecological consequences (Gunders, 2012). Food composting can create goodwill in the local community through visible relationships between consumers, farmers and business owners (Gunders, 2012). For foodservice operators, regular composting can result in significant money and energy savings due to reduced hauling of solid wastes to the landfills (Griffin et al., 2009; Stuart, 2009).

According to Kwon et al. (2010) some barriers to effective composting include: limited access to composting sites, complexity inherent in composting certain food types, inadequate training, inconsistent and sometimes lack of financial support, and lack of proactive policies. Gunders (2012) maintains that these challenges have to be eliminated if meaningful food composting is to take place in food service institution settings. She found that, even with the existence of accessible methods to create value from food waste, in the US only 3 percent of the total uneaten food is composted. The majority is sent to landfills: food is the largest constituent of municipal solid waste hauled to landfills every day. Yet, decomposition of this uneaten food is responsible for America's 23 percent of total methane emissions (Gunders, 2012).

2.9. Conclusions

While food losses and wastes occur throughout the food supply chain, food losses are typically limited to the early phases i.e. during and after harvest. Whereas food waste occurs in the last and final phases of the food supply chain, namely; retail and final consumption.

Although studies report varied food loss and waste figures, they all agree that consumer food waste contributes highest to the overall food losses and waste. Likewise, plate waste is the single largest contributor to consumer food waste. In the developed economies, consumer food waste is mainly due to wasteful, bad eating behaviours and easy access to relatively cheap food. In developing economies, rapid expansion of technological and economic development and urbanisation significantly enlarge the relatively inefficient FSC resulting into significant food wastage. Nonetheless, in both economies, food wastage represents unnecessary and avoidable socio-economic and ecological consequences.

A method used to establish magnitude of food wastage in a given phase of the food supply chain depends on the study's objective and desired outcome. In food service institutions, specifically Universities dining facilities, individual weighing of plate waste is the most appropriate method as it provides relatively more accurate and most detailed information on plate waste.

While the causes of food plate waste in food service institutions may be dependent on the type of institution, the majority of causes are comparable. They can be broadly classified into three main categories namely; operational, situational and behavioural causes. While operational causes depends on a food service institution policies and practices, situational causes refer to the wider environmental factors that influence such practices. Behavioural causes entail individual consumers' behaviours and attitudes towards food and are usually beyond the control of the FSI.

Reducing food plate waste is a complex phenomenon that requires a multifaceted approach that involves sequential trial and appraisal of potentially effective approaches. Approaches such as 'offer versus serve', appropriate scheduling, reducing size of eating utensils, improving food quality and acceptability, transforming menus to offer a range of food choices, among others, can work to lower waste. Essentially, to reduce plate waste, a FSI operation need to operate under certain prerequisites. These include appropriate catering service system, regular staff training, appropriate consumers' education and regular food waste auditing, to name a few.

Due to its complexity and intricacy, complete elimination of food waste in foodservice is not achievable. Even so, technological advancements permit creation of value from food that is left as waste. Food recovery and distribution helps improve regions' food security and provide tax benefits while reducing food waste quantities that enter landfills.

Chapter 3 - Research Methodology

3.1. Study location

This study was conducted in Metanoia Hall - a 501-bed students' residence facility located within Stellenbosch University (SU) main campus, Stellenbosch, South Africa. The University subcontracts the purchase of food items, preparation and service to FEDICS - a food company that offers catering services to businesses, corporates, schools, colleges, hospitals and other health care facilities.

Located within Metanoia residential hall is Metanoia dining facility which is open every day of the week (except holidays). Each day, the Metanoia central food kitchen prepares and serves three meals i.e. breakfast, lunch and dinner. Within the dining facility are two call order bars that sell different foodstuffs such as burgers, wraps, sandwiches, chicken, chips etc. (Swartz, 2014). To be served meals from the central kitchen, students have to book at least 48 hours before the meal time. Likewise, cancelling an already booked meal is only possible at least 48 hours before the meal time. A variety of food items are served. Students are charged differently: they pay for the food items or options that they choose.

Within the dining facility, tables are arranged with spaces between them to allow movement. On entering the food serving facility, students, pick up a dining tray and proceed to swipe their identity cards on a computer. Swiping of student identity cards enables the catering staff serving meals to distinguish the meal option each student booked. Using standardised serving utensils, students are served meals that they booked. When done eating, students return the soiled plates and trays to movable tray holders located at various positions within the dining facility, from where they are collected by kitchen staff for washing.

In Metanoia, FEDICS uses a season-based menu (a cycle menu typology), which means that different food items are served during summer and winter seasons. For every meal, there are different food options: five food options during breakfast, another five options for lunch, and seven options for supper. This is valid for weekdays only. During the weekends, only three food options are available per meal. The full food options and menus constructed from these options are presented in Table 3.1. The menu followed during the two days in which this study was conducted is shown in Appendix B. It should be noted that only the menu followed during the two occasions of investigations have been presented.

Table 3.1 Metanoia food options and menus

Food options	Menu types
• Dessert	• Standard meal
• Cereal	• Vegetarian
• Salads	• Get-balanced
• Vegetables	• Salad select
• Starch/carbohydrates	• Better burger
• Proteins	• Steakhouse lunch
• Fruit juice	• Lunch at dinner
• Yoghurt	• Bcombo
• Fruit	• Take a way
• Tea/coffee	

3.2. Data collection

The methodology for plate waste measurement was adapted from those described by Comstock et al. (1979) and Nichols et al. (2002). To avoid biased food eating behaviour among the students during the study, unannounced days were chosen and students were not informed of the impending study.

Stellenbosch University's Research Ethics Committee approved the study protocol used in this research (Ref: DESC/Alooh/May2014/33). To ensure anonymity, study participants were asked not to indicate their names or student identification numbers anywhere in the questionnaire. No other personal information was collected from the participants.

During weekdays the central kitchen opens from 7.30 am to 9.00 am for breakfast, 12.30 pm to 1.30 pm for lunch and 5.45 pm to 7.00 pm for dinner. Plate waste weight measurements were carried out only during these periods and on two occasions. Babich and Smith (2010) evaluated the magnitude of plate waste generated from Southern Illinois University students dining facilities over a two day period while Sarjahani et al. (2009) carried out similar study in Virginia Polytechnic Institute and State University dining halls over a five-day period. Likewise, using a sample size of 60 clients, Nichols et al. (2002) estimated plate waste in a community retirement living centre over a three day period. The duration of the current study was informed by that by Babich and Smith (2010).

The first occasion, hereafter referred to as the first study, was carried out on 6th May 2014 while the second occasion was on 21st May 2014. Comstock et al. (1979) recommends a period of at least seven days between any two rounds of plate waste investigation. Further, during the two studies, four Stellenbosch University students were recruited as research assistants and trained on measurement of plate waste. Training was done using written guidelines adapted from literature on similar studies (Comstock et al., 1979; Nichols et al., 2002). An oral session to clarify on unclear issues was also held. On the days of investigation, research assistants arrived at the dining facility at least one hour before meals were served to set up study apparatus at the work station. The menu-list of meals/foods that were to be prepared and served on the days of investigation was obtained prior to the study day for the necessary preparations. These preparations included setting up of a table where food plate waste weight was captured and labelling buckets for aggregation of similar food items.

When students were done eating and before they took their trays (with the leftovers, if any) to the tray holders, the RA intercepted the soiled trays, scraped and sorted out the leftovers and weighed them. The gender of the student was indicated at the place and time of tray interception. Edible portions of the leftovers constituted the food wasted while the inedible portions e.g. banana peels and chicken bones were discarded appropriately. After their trays were collected and before they left the dining facility, students were asked to complete a food waste questionnaire. Students were asked to complete the questionnaire only once in a day, for example, those who completed the questionnaire during breakfast were not allowed to complete the questionnaire during lunch or dinner. To enforce this, students were asked if they had already completed the questionnaire.

Scraping and sorting plate waste

Scraping and sorting was done to separate the plate leftovers into edible and inedible portions. Inedible portions including bones, fruit peels and seeds were put in a separate container and equally weighed after which they were discarded via the dining hall's garbage disposal system. For example chicken was weighed without bones and banana without banana peels. Likewise, all condiments and other top dressings were scraped off from all the food waste. Separation of individual food components from each other was done as comprehensively as possible and without excessive labour. However, due to food preparation methods, small contaminations could not be avoided.

To estimate the initial weight of the foods served, three representative meal servings were randomly selected and weighed before each meal (Comstock et al., 1979). This value was used as the initial food weight in data analysis.

Categorisation of plate waste

To assess the content of plate waste by each student, the plate waste collected was categorised into individual food types/components hereafter referred to as food items. During the two rounds of survey, the encountered food items included fruits, bread, cereals, rice, pasta, pizza crusts, beef sausages, beef, eggs, macaroni, custard and vegetables and salads. For analysis purposes, the vegetables and salads category included both raw and cooked vegetables and salads. Furthermore, although cereals and milk are usually mixed prior to consumption, they were separated during the waste assessment. However, this study did not estimate wastage of fruit juices and condiments.

Weighing

During sorting, individual food types were transferred into a weighing plastic container. The empty weight of the container was determined and recorded prior to the collection of plate waste. Weighing was done using a Saxony Kitchen Scale. All weight readings were taken to the nearest 0.1 grams. The weighing scale was reset to zero every time a new reading was to be taken.

Sampling procedure

The sampling procedure proposed by Comstock et al. (1979) was used. Information on the total number of students expected to be served meals (i.e. the number of students who booked meals on the days that the plate waste study was carried out) was obtained from the kitchen manager.

According to Comstock et al. (1979), the sampling ratio should be 1 if the number of students expected to be served is 300 or less; otherwise, the sampling ratio should be computed as 300 divided by the total number of students who booked meals. For example if 700 students are to be served then the sampling ratio is 300/700 which equals to 3/7 or 0.429. This is then rounded off to the nearest simple fraction which guarantees a sample size of 300. During the two rounds of this study, less than 300 students booked meals. Accordingly, this study assessed plates of all the students who booked meals.

Questionnaire development

Sources of questions

Previous research findings on food plate studies (Kelly, 1999; Collison and Colwill, 1987) within food service institutions were used to develop questions. To identify questionnaire sources, a literature search method used by Williams and Walton (2011) was adopted. That is, original and peer reviewed articles published in English from databases such as Sage, Scopus, PubMed and Elsevier were evaluated. Various groupings of words such as 'causes of food waste', 'University dining facilities', 'plate waste' were employed during the literature search in these databases. List of references from the retrieved articles were examined individually to extend the scope of search. While primary focus was on articles on plate waste in University settings, studies from other food service institutions e.g. elementary schools, were used for comparison purposes.

Meetings were held in February 2014 with management personnel in charge of property and environmental services at Stellenbosch University (SU) to develop a preliminary understanding of the extent of the food waste problem and related waste management issues on the campus and at the halls of residence in particular. During the first meeting, the following issues were explored:

1. The extent to which the problem of waste generated from dining facilities is monitored and tracked. It emerged that the University does not audit waste from the dining facilities. However, a figure of the total amount of organic waste as analysed from waste bins within campus exist which showed that SU strongly promotes waste recycling, and this suggested that knowledge of the magnitude of food waste from dining facilities would be vital as part of a precondition for cost-effective waste management.
2. If food plate waste is a problem within campus dining facilities; to avoid investigating what isn't really a problem. It come out that the level of plate waste within dining halls is not known. Neither are the reasons for such wastes. It was considered that an investigation into the magnitude and causes of plate waste would indicate whether plate waste is a problem or not. It was thought that due to a probable role of food menus in reducing plate waste, menu's popularity among students should be assessed. So was students' awareness of food waste as a problem. Moreover, students behaviours e.g. how often they book meals but never show up to dine was to be assessed.

The second meeting held on 10th March 2014 with SU contract manager was recommended during the first meeting, in part, to obtain permission to access a dining facility for the proposed research study. The meeting resolved that there is an inadequate understanding of food waste within SU dining facilities, hence, an investigation into plate waste would go a long way in helping design and execute food waste minimisation strategies within SU campus.

Contents of the questionnaire

Contents of the questionnaire developed and used in the research are shown in Appendix A while Table 3.2 summarises the food aspects evaluated. A Likert scale, ranging from 'always' to 'never', was used to assess how often students leave plate waste and the frequency with which they turn up to eat meals they book. Likert scales are psychometric response scales predominantly used in questionnaires to asses participant's opinions with statement(s) (Jamieson 2004). In this study, participants were asked to rate the quality of the meals they ate using a five point Likert scale ranging from 'especially good' to 'especially poor'. Menu popularity, participants' conceptualisation of plate waste as a problem and their awareness of the same, were assessed using a five point Likert scale ranging from 'especially good'-'especially poor', 'a great deal'-'not at all' and 'little/no problem'-'very great problem', respectively. Table 3.3 sums up the questionnaire questions and the corresponding Likert scale used.

Table 3.2 Food waste attributes evaluated

Attribute	Questions
Plate waste behaviour (2 items)	1 and 9
Food quality and quantity (3 items)	2, 3 & 5
Menu popularity (2 items)	4 & 6
Plate waste as a problem (1 item)	7
Plate waste awareness (1 item)	8
Addressing plate waste (1 item)	10

Table 3.3 Likert scales types used in questionnaire

Question	Likert scale
1	'Always to never'
3	'Especially good to especially poor'
4	'A great deal to not at all'
7	'Little/no problem to very great problem'
8	'Not at all aware to extremely aware'
9	'Always to never'

Questionnaire testing

Prior to the two Metanoia food plate waste studies reported in this study, the questionnaire was tested on a sample of ten students who volunteered during a preliminary survey to assess the comprehensibility and the ease with which participants would answer the questions. Feedback from this initial survey was valuable in refining the text and response options, thereby enhancing the validity and reliability of the final questionnaire.

During the testing exercise as well as the main study days, the contents of questionnaire were introduced and discussed before handing to study participants. This ensured that only students who were willing to complete the questionnaire were provided with a copy.

3.3. Data analysis

Data analysis was done using Microsoft Excel 2013 (Microsoft Corporation®, Redmond, WA) and Statistica for Windows version 12.0 (Statsoft Iberica, Portugal). All statistical tests were carried out with a statistical significance level set at $p<0.05$.

Quantification of food plate waste

Food plate waste quantity analysis and results presentation was done at two levels. The first level of analysis was to characterise food plate waste *only* for the diners/students who left plate waste while the second level was used to characterise plate waste for all students (entire dining facility) who booked meals in the dining facility.

Data was analysed to quantify the amount of food wasted (kg) for individual student and overall percentage food waste (Nichols et al., 2002; Comstock et al., 1979):

$$\frac{Amount\ of\ food\ wasted}{Amount\ of\ food\ served} \times 100\ \text{(Equation 1)}.$$

The amount of food waste was estimated by subtracting the weight of edible uneaten food (kg) from the initial amount of food served. Equally, weight of inedible food portions were subtracted from the amount of food served to determine the edible weight of served food.

To estimate the total amount of food waste in the dining hall, it was assumed that all students who booked meals turned up for meal. While the best way to estimate the amount of food served was to use only the number of actual students who turned up to dine (since 100 percent attendance is very unlikely), this information could not be accessed.

Mean plate waste was computed for the individual food items served during each of the three meals of the day i.e. during breakfast, lunch and dinner. Student gender was also recorded for each plate assessed. Overall mean plate waste per day was determined using the average of mean wastes of these three meals.

Cost of food plate waste

The cost of food plate waste was calculated and presented in South African Rands. The retail prices of the food items wasted were obtained from local supermarkets during the period of study. For each type of food product, the average retail prices at three major supermarkets namely: Pick 'n Pay, Shoprite and Spar were used.

It is acknowledged that the best price to utilise in calculating the cost of plate waste would be those paid by FEDICS (the catering establishment that cooks and serves food in Metanoia) when they purchased the food items, better still, using the prices paid by the majority of consumers. However, due to confidentiality reasons in both cases, these prices could not be obtained. Thus, the average price of food items obtained from the local supermarkets on the days the studies were carried out were used to estimate the cost of food plate waste.

Questionnaire data

The mode, median and interquartile range (IQR) of Likert all scale data were calculated. While the mode and mean shows the most provided responses and the middle of a data set, respectively, the interquartile range (IQR) (Quartile$_3$-Quartile$_1$) shows where the 'middle fifty' of a data set lies i.e. where the majority of the values are located. In an ordinal data (such as those obtained from a Likert scale), the IQR measures how spread out the data points are from the mean of the data set. High IQR denotes a more even data points whereas a smaller IQR depicts that the data are more clustered around the mean (Graham, 2008). Spearman's correlation rank (r_s) was calculated to test significant relationships in the Likert scale questions. r_s is a statistical measure of the strength of a monotonic relationship - one that either never increases or never decreases as its independent variable increases between paired data (Statistics How To, 2014).

Chapter 4 - Results and discussion

4.1. Quantity of food plate waste

Trays with unfinished food items

The percentage of students in the Metonaia halls of residence who waste food was estimated from the number of trays with unfinished meals. During the two studies, the total number of trays served was 924 out of which a total of 378 trays had food plate waste (Table 4.1). This showed that 41 percent of the students who were served left some food on their plate, and hence the remaining 59 percent represented students who ate all their meals. Interestingly, an interview with the kitchen manager revealed that there were no food leftovers (food prepared but not served) during the two studies. This suggested that some students were served more food portions than they booked, assuming that the kitchen prepares fixed food portions for students who book meals.

Whitehair et al. (2013) assessed plate waste in a dining facility at Kansas State University and reported that 61 percent of students did not leave edible food portions after eating. This is comparable to 59 percent found in the current study, suggesting a similarity in the proportion of diners who leave food portions in these two dining facilities.

Table 4.1 Number of trays served and plate waste during each meal and date

Meal	Breakfast		Lunch		Dinner		Total number of trays
Day	First study (06/05/14)	Second study (21/05/14)	First study (06/05/14)	Second study (21/05/14)	First study (06/05/14)	Second study (21/05/14)	
Total number of trays served	49	40	164	253	193	225	924
Total number of trays with FPW	24	15	90	108	68	73	378
Percentage of trays with FPW	49	38	55	43	35	32	Overall mean = 41%

Aggregate plate waste

During the two studies, total food plate waste recorded was 39.37 kg (Table 4.2). Overall, 19.17 kg of food waste was generated during lunches, 16.75 kg during dinners and 3.46 kg during breakfasts. A trend exists in these food waste quantities. The largest amount of plate waste was recorded during meals with the highest number of attendance, which showed that lunch had the largest quantity of plate waste (19.17 kg) and attendance (198) followed by dinner (16.75 kg and attendance 141) and breakfast (3.46 kg and attendance 39). However, interestingly, lunch had the smallest value of mean percentage plate waste (36.47 ± 2.50 percent per day), followed by dinner (39.61 ± 2.16 percent per day) and breakfast (45.17 ± 1.48 percent per day) (Table 4.2). These trends confirm the argument put forward by Ferreira et al. (2013) that the quantity of plate waste depends on the quantity of meals served and the specific food quantity.

Table 4.2 Overall meal attendance, quantity and mean of food plate waste

	Number of students	Quantity of food plate waste (kg)	Percentage Mean Plate waste (mean ± standard deviation)
Lunch	198	19.17	36.47 ± 2.50
Dinner	141	16.75	39.61 ± 2.16
Breakfast	39	3.46	45.17 ± 1.48
Total	378	39.37	40.42 ± 2.05 (Overall mean)

Furthermore, Ferreira et al. (2013) contended that the higher the quantity of food served the higher the quantity of food plate waste and vice versa. In the current study, the greatest quantity of food plate during lunch (compared to dinner and breakfast) is because the highest number of students were served meals during this meal. The relatively high average food plate waste per student during dinner suggested that a higher amount of food waste was generated by comparatively small number of students. Tables 4.3 to 4.8 present the mean percentage waste of food items served during each meal for the two studies.

Table 4.3 Breakfast food plate waste. First study (06/5/2014)

Food Items	n	Mean Plate Waste (%) $N_1=24$	Mean Std. Dev (%)	Overall Plate Waste (%) (N=49)
Fruit (Breakfast)	2	56	62	2
Vegetables and Salads (Breakfast)	10	49	30	10
Bread (Breakfast)	9	48	33	10
Cereal (Breakfast)	10	47	31	11
Cheese (Breakfast)	1	8	*	0.1
Beef Sausages (Breakfast)	8	51	37	10
Yoghurt (Breakfast)	6	74	40	9
Eggs (Breakfast)	12	39	34	10
Sex (M)	32	53	35	-
Sex (F)	26	45	33	-
Mean	58	49	34	6.5

*No Standard Deviation, Only one observation made
n=number of food items used in analysis
N=number of students who booked meals
N_1=Number of students with FPW
M=Male
F=Females

Mean plate waste refers to the proportion of food that was served but not eaten. For example a mean waste of 56% in fruits indicate that only 44% of served fruits were actually consumed.

Table 4.4 Breakfast food plate waste. Second study (21/5/2014)

Food Items	n	Mean Waste (%) $N_1=15$	Mean Std. Dev (%)	Overall Plate Waste (%) (N=40)
Vegetables and Salads (Breakfast)	7	71	22	13
Bread (Breakfast)	5	54	44	7
Cereal (Breakfast)	9	19	32	4
Porridge (Breakfast)	1	85	*	42
Cheese (Breakfast	5	41	34	23
Eggs (Breakfast)	7	35	32	9
Yoghurt (Breakfast)	2	8	11	0.4
Sex (M)	19	41	40	-
Sex (F)	17	42	32	-
Mean	36	41	36	7

Table 4.5 Lunch food plate waste. First study (06/5/2014).

Food Items		Mean Waste (%)	Mean Std. Dev (%)	Overall Plate Waste (%)
	n	N₁=90		(N=164)
Fruit (Lunch)	1	99		0.6
Vegetables and salads (Lunch)	82	29	18	14
Bread (Lunch)	47	47	25	14
Spaghetti (Lunch)	27	19	14	4
Custard (Lunch)	34	50	25	11
Beef Sausages (Lunch)	2	50	15	14
Sex (M)	110	36	25	-
Sex (F)	83	36	22	-
Mean	193	36	24	7.5

Table 4.6 Lunch food plate waste. Second study (21/5/2014)

Food Items		Mean Waste (%)	Mean Std. Dev (%)	Overall Plate Waste (%)
	n	N₁=108		(N=253)
Vegetables and Salads (Lunch)	83	40	23	13
Bread (Lunch)	15	78	30	5
Cake (Lunch)	42	40	23	7
Potatoes (Lunch)	37	9	9	1
Chicken (Lunch)	7	34	31	1
Fruits (Lunch)	3	31	22	0.4
Beef mince (Lunch)	3	45	10	8
Sex (M)	96	40	30	-
Sex (F)	94	33	24	-
Mean	190	37	27	5.3

Table 4.7 Dinner food plate waste. First study (06/5/2014)

Food Items		Mean Waste (%)	Mean Std. Dev (%)	Overall Plate Waste (%)
	n	N_1=68		(N=193)
Fruit (Dinner)	4	84	11	2
Vegetable and salads (Dinner)	35	30	27	6
Bread (Dinner)	8	56	23	2
Soup (Dinner)	11	41	31	3
Macaroni (Dinner)	4	41	23	8
Pizza crusts (Dinner)	18	30	23	3
Rice (Dinner)	48	59	21	18
Beef Sausages (Dinner)	7	53	37	23
Sex (M)	65	52	26	-
Sex (F)	70	40	30	-
Mean	135	46	29	7.0

Table 4.8 Dinner food plate waste. Second study (21/5/2014)

Food Items		Mean Waste (%)	Mean Std. Dev (%)	Overall Plate Waste (%)
	n	N_1=73		(N=225)
Fruits (Dinner)	7	45	23	1
Vegetables and Salads (Dinner)	66	27	15	8
Bread (Dinner)	13	65	32	4
Macaroni (Dinner)	25	28	30	4
Beef sausages (Dinner)	3	60	37	1
Sex (M)	62	31	25	-
Sex (F)	52	36	26	-
Mean	114	33	25	4.4

On plate waste during each meal, the current study's finding that breakfast had the least quantity of food plate waste concurs with that of Sarjahani et al. (2009) who reported lowest plate waste by weight during breakfast (133.9 kg) compared to lunch (311.7) and dinner (547.7 kg) in a dining facility at Virginia University, USA. However, current research findings differ from those by Zakiah et al. (2005) who reported least plate waste during breakfast (31.3 ± 27.5) followed by lunch (43.3 ± 26.1) and dinner 53.3 ± 33.8), in a Malaysian hospital. This suggests that the current study's diners wasted more food during lunch (compared to dinner) relative to the dinners surveyed by Sarjahani et al. (2009) and Zakiah et al. (2005).

The overall mean plate waste by weight for the entire dining facility during the two studies was 6.35 ± 1.25 percent per day, that is, 7.02 ± 0.53 and 5.67 ± 1.51 percent per day during the first and second study respectively (Table 4.9). Similar to only students who left plate waste, breakfast had the highest average waste per student followed by lunch and dinner. These figures were calculated based on the total amount of food served in this dining facility (which is

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dictated by the total number of students who booked meals) during the two studies. They are different from the mean plate waste (40.42 ± 2.05 percent) which only considered those students who had plate waste.

Table 4.9 Mean (percent) food plate waste: entire dining facility

Study	Breakfast	Lunch	Dinner
First study (6/05/2104)	5.52	7.58	6.95
Second study (21/05/2014)	7.35	5.26	4.41
Mean	6.44	6.42	5.68
Standard Deviation	1.29	1.64	1.80

Different amounts of plate waste have been reported in food service institutions operating within learning environments. Engström and Carlsson-Kanyama (2004) reported 11 to 13 percent plate waste among Swedish schools and food restaurants while Ferreira et al. (2013) found a 0.2 kg average waste per student and 30 percent mean plate waste from an entire Portuguese University dining facility. Buzby and Guthrie (2002) reported a 12 percent plate waste in the United States National School Lunch Program (NSLP) which was down from 24 to 35 percent reported by Getlinger et al. (1996) in the same program after government efforts to cut food waste.

All these results differ from the current study's overall mean plate waste for the entire dining facility (6.35 ± 1.25 percent) as well as that of students who left plate waste (40.42 ± 2.05 percent). Connors and Rozell, (2004) and Sarjahani et al. (2009) suggested that breakfast meals should be excluded from mean analysis because breakfast menus, unlike lunch and dinner are usually unpopular among diners. Furthermore, due to unestablished reasons, relatively few clients turn up to eat breakfast meals (Connors and Rozell, 2004). As regards the current study, excluding breakfast meals from the calculation mean plate waste lowers the average plate waste to 38.04 ± 2.33 for students who left plate waste and 6.05 ± 1.47 for the entire dining facility.

Considering that other plate waste studies in University settings have reported plate waste values of between 11 and 30 percent (Ferreira et al., 2013; Al-domi et al., 2011; Sarjahani et al., 2009), the current study's entire dining facility's mean plate waste of 6.35 ± 1.25 percent may be considered acceptable. Further, excluding breakfast meals from the analysis mean reduces the value of mean waste for the entire dining facility to 6.05 ± 1.47 which may still be regarded as acceptable.

However, the absence of previous studies that have analysed plate waste *only* among those who leave food waste limits considering the 38.04 ± 2.33 percent plate waste as acceptable or not. However, the mean plate waste does not depend on the number of students/diners surveyed, rather, on the amount of food served (Ferreira et al., 2013). As such, one expects the mean plate waste among students who left plate waste to equate to the mean waste of the entire dining facility.

Average food plate waste

During food plate waste assesment over a five day period, Sarjahani et al. (2009) obtained 0.257 pounds (equivalent to 0.117 kg) plate waste per student per day at a dining facility in Virginia Polytechnic Institute and state University. Similar to the current study's dining facility, this dining facility served food to students using trays. The average plate waste of 0.117 kg per student is not significantly different from current study's 0.105 kg per student (Tables 4.10 and 4.11) among those who had plate waste. However, when the entire dining facility is considered, 0.117 kg per student is about three times higher than the results obtained from the current study (0.04 kg per student). This suggests that overall, the average food plate waste among students of the current research is significantly lower than those evaluated by Sarjahani et al. (2009).

Nevertheless, Babich and Smith (2010) found a mean plate waste of 1.04 ounces (0.03 kg) per student per day over a two day period from Southern Illinois University students dining facilities. This result is comparable to the average plate waste for the entire dining facility (0.04 kg) found in the present study. This suggests that the magnitude of plate waste among students of current study in Stellenbosch University, South Africa (developing country) is similar to that of Southern Illinois University, USA (a developed country). This seems to contradict the contention that the quantities of consumer food waste significantly differ between more and less economically developed countries with almost no consumer food waste generated by consumers in less developed countries (Gustavsson et al., 2013; Lipsinki et al., 2013; FAO, 2011). However, South Africa is typified by a hybrid of two parallel economies, to wit: the 'formal' economy, which is fundamentally comparable to those of most developed countries and a 'marginalised' economy (Oelofse and Nahman, 2012). Differences in economic development levels between South African population and those of the developed world may account for these differences in plate waste results.

It should be noted that the 38.04 ± 2.33 mean percentage plate waste represents food waste among only those students who did not complete their food (alternatively, trays with plate waste). The overall plate waste from the entire dining facility stood at 6.35 ± 1.25 percent. As described in the methodology chapter, the current study carried out analysis at two distinct levels i.e. students who left plate waste as well as the entire dining facility. The benefit of such a two level analysis is that it enables assessment of the level of intensity of plate waste within students who leave plate waste as well as the entire group of diners. This eliminates the typical underestimation when only plate waste of the whole dining facility is assessed. This argument is validated by the comparatively low entire dining facility plate waste of 6.35 ± 1.25 percent compared to 38.04 ± 2.33 percent for *only* the diners who left food on their plate. This indicates that while the overall level of plate waste within the *entire* dining facility may be acceptable, the level of plate waste generated by students who left plate waste is far higher than is acceptable.

A survey of literature reveals that no plate waste study in University dining facilities has ever been performed with such a two level analysis of results. Therefore, it can be concluded that the absence of information on the quantity of plate waste among diners who leave portions of their food uneaten may be responsible, in part, for the absence of effective measures to curb food waste within such facilities. This is because the overall plate waste for the entire dining facility is usually considered as low and acceptable.

Table 4.10 Quantity and average of food plate waste first study (6/5/2014)

	Amount of FPW (kg)	Total number of students (with FPW)	Total number of students (entire dining facility)	Average waste per student (with FPW) Kgs/student	Average waste per student (entire dining facility) Kgs/student
Breakfast	2.3	24	49	0.1	0.05
Lunch	9.11	90	164	0.1	0.06
Dinner	10.61	68	193	0.16	0.05
Total	22.02	182	406	0.12	0.05

Table 4.11 Quantity and average of food plate waste second study (21/5/2014)

	Amount of FPW (Kgs)	Total number of students (with FPW)	Total number of students (entire dining facility)	Average waste per student (with FPW) Kgs/student	Average waste per student (entire dining facility) kg/student
Breakfast	1.15	15	40	0.08	0.03
Lunch	10.06	108	253	0.09	0.04
Dinner	6.14	73	225	0.08	0.03
Total	17.36	196	518	0.09	0.03
Average food plate waste (for the two rounds)	-	-	-	0.1	0.04

4.2. Plate waste among food items

While different food items were served during different meals of the day, categorisation of plate waste revealed that fruits, vegetables and salads and bread were served during each meal. There were statistical differences in mean percentage plate waste of different food items during all meals except during breakfast of the first study (Figures 4.1 to 4.9). This suggests that students wasted the different food types in varying quantities. For instance, students who left uneaten food portions wasted 48 percent of bread during first study's lunch and 78 percent during second study's lunch. These results suggest that every food item had equal chance of being wasted. Therefore, measures to reduce food plate waste within the dining facility should target all the food items during every meal of the day. Nonetheless, special attention should be paid to breakfast due to the apparent low turnout and high quantity of food plate waste. This is because the high number of meal booking but low number of attendance may increase the quantity of plate waste.

Figure 4.1 Food items mean plate waste. First study breakfast

Figure 4.2 Food items mean plate waste. First study breakfast. Selected food items

Figure 4.3 Food items mean plate waste. Second study breakfast

When comparing two means, presence of a common overlapping letter between the means e.g. "a" vs "ab" implies that the means are not significantly different. However, absence of a common letter e.g. "a" vs "bc" implies that the means are significantly different.

Figure 4.4 Food items mean plate waste. Second study breakfast. Selected food items
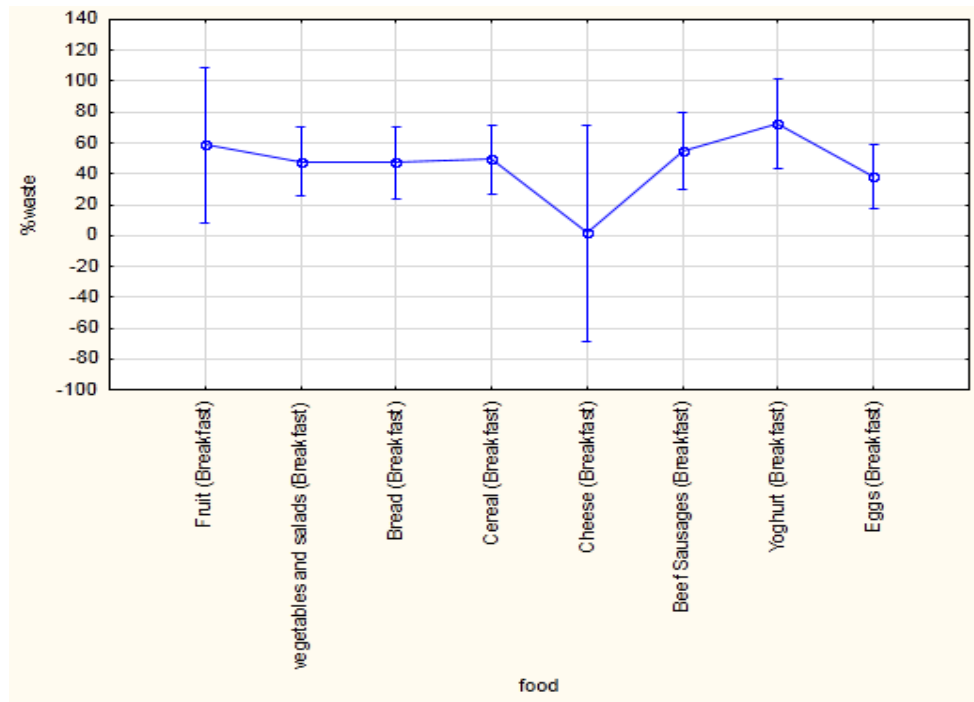
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Figure 4.5 Food items mean plate waste. First study lunch

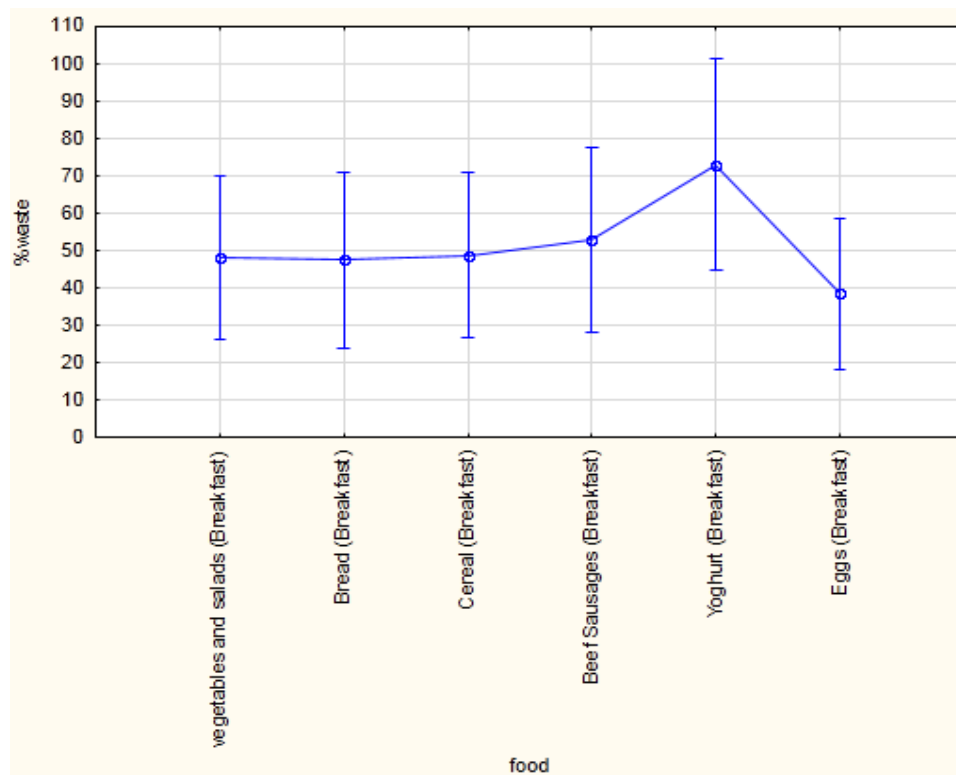**Figure 4.6 Food items mean plate waste. First study lunch. Selected food items**

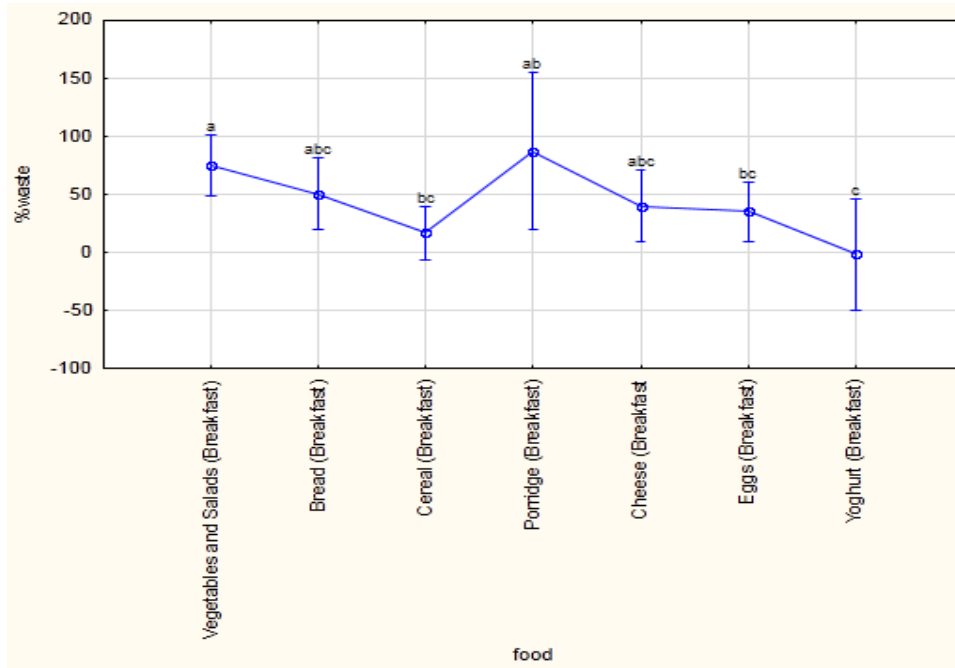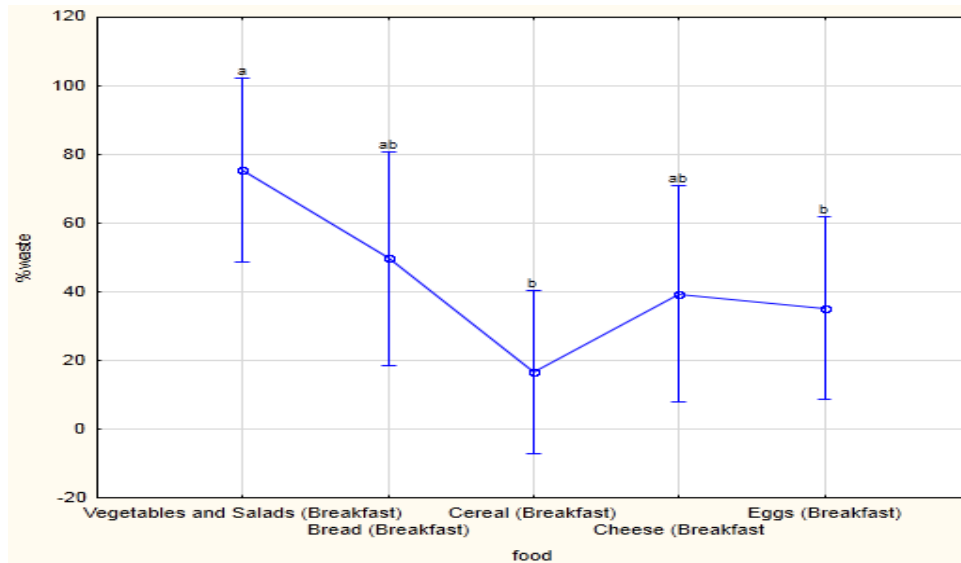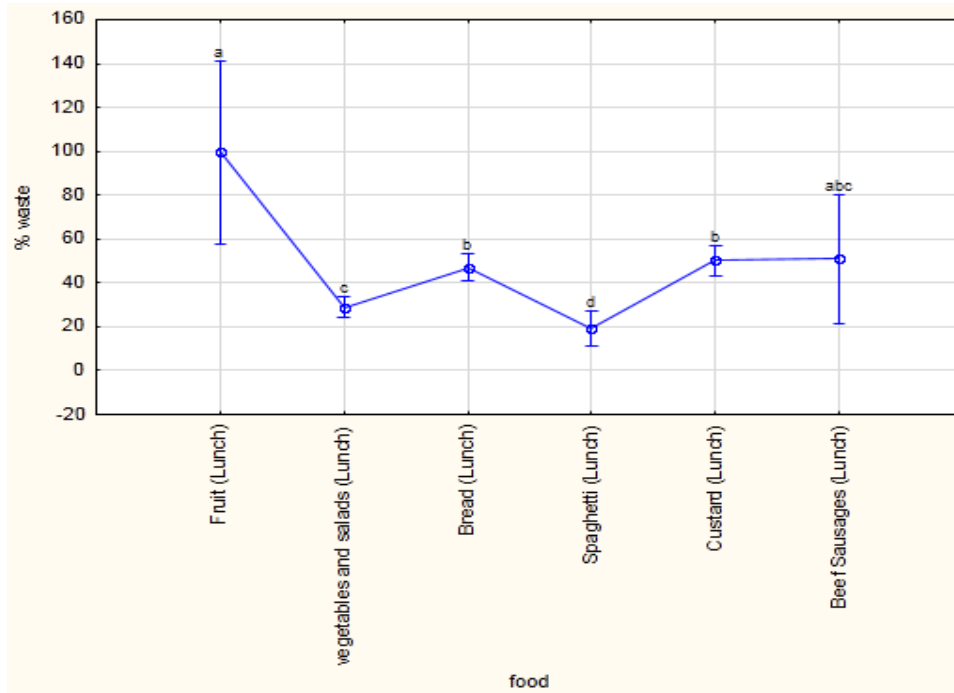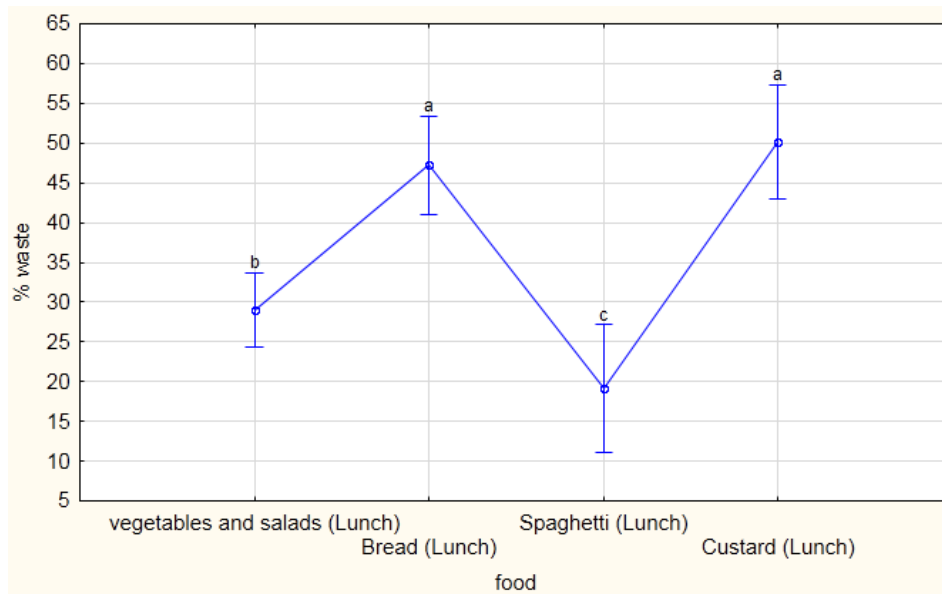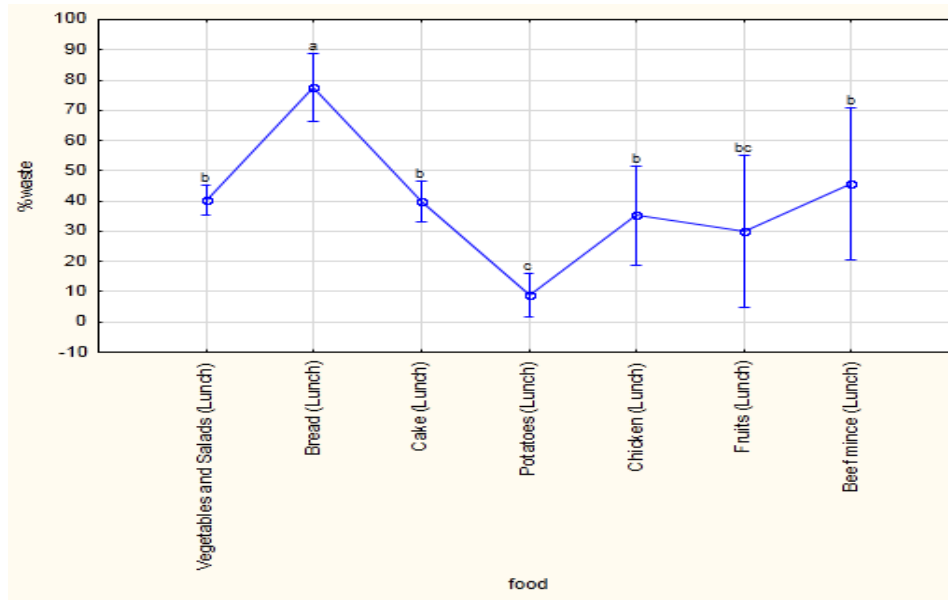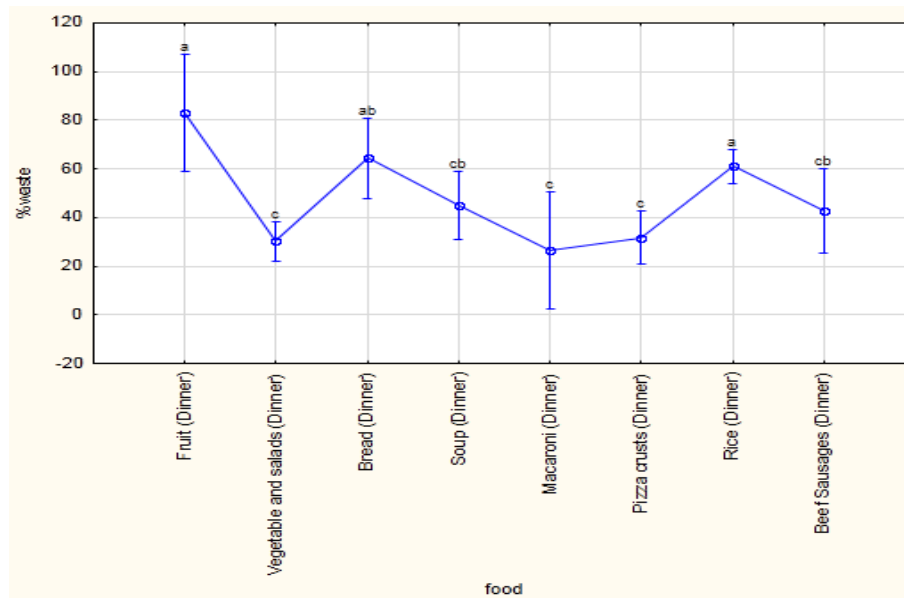**Figure 4.7 Food items mean plate waste. Second study lunch**

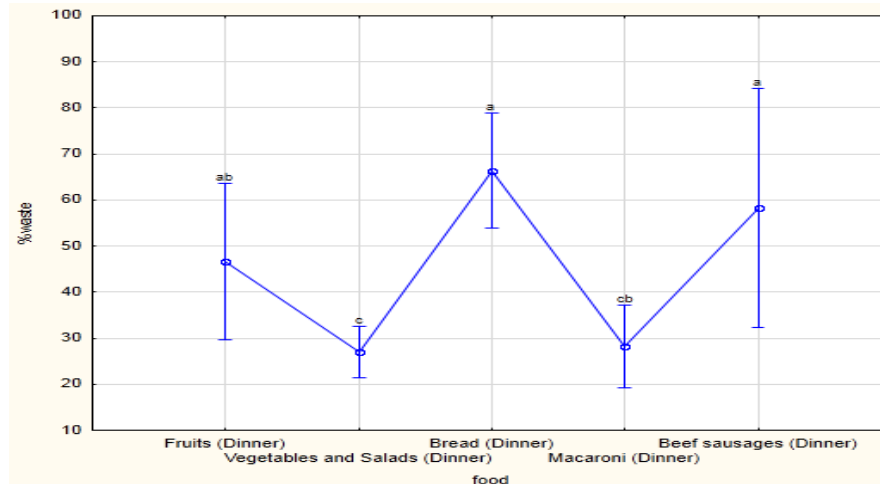**Figure 4.8 Food items mean plate waste. First study dinner**

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Figure 4.9 Food items mean plate waste. Second study dinner

These results agree with the findings of Buzby and Guthrie (2002) that the quantity of individual food item consumed directly dictates the quantity of food waste. However, it has been contended that the quantity of food waste also depends on a combination of other factors, chiefly, student energy requirements, tastes and preferences (Al-domi et al., 2011; Freedman and Brochado, 2010; Buzby and Guthrie, 2002).

While various food items were wasted in dissimilar quantities, vegetables showed the highest waste quantity during each meal indicating that relatively low quantities were consumed. This finding corresponds to those by WRAP (2009) and Cohen et al. (2013) which showed that vegetables constitute the highest quantity of waste within UK consumers and US students respectively. However, in the current study, relatively high waste of vegetables may be due to dissimilar individual food tastes and preferences. The other reason, in part, could be that vegetables and salads, unlike the rest of the food items, were served during all the meals. This means that the amount of vegetables and salads served was higher than other food items. This explains their high waste since the quantity of food served directly dictates the quantity of plate waste (Ferreira et al., 2013; Hackes et al., 1997).

While various food items were wasted in different quantities, a comparison of food items (Tables 4.3 to 4.8) revealed that overall, bread was wasted more than vegetables and salads, i.e. 58 percent against 41 percent. This finding opposes those by WRAP (2009), Zakiah et al. (2005) and Cohen et al. (2013) which showed that vegetables constituted the highest quantity of waste among UK consumers, Malaysian hospital patients and US students, respectively. However, in the current study, relatively high waste of bread compared to vegetables and salads may be due to different individual food tastes and preferences (Nichols et al., 2002). On the other hand, the high quantity of plate waste in bread and vegetables and salads compared to all the other food items may be because they were served during all the meals. This means that the amount of bread and vegetables and salads served was higher than other food items. This explains their high waste since the quantity of food served directly dictates the quantity of plate waste (Ferreira et al., 2013; Hackes et al., 1997).

Waste in food items: comparison of study one and study two
Breakfast

Overall, there was no significant statistical difference (p=0.48186) in plate waste among food items during first study's breakfast. Yoghurt generated highest waste (74 percent) while cheese recorded the least (8 percent) (Table 4.3). Vegetables and salads, bread and cereals did not show significantly different mean waste (49, 48 and 47 percent correspondingly). There were no significant statistical differences in mean percentage waste of all the food items wasted during this meal (Figure 4.1).

During the second study, with only one observation (number of who left edible food portions), porridge generated the greatest waste at 85 percent (Table 4.4). Vegetables and salads followed at 71 percent waste while yoghurt had least waste-8 percent. However, one would expect lower plate waste with yoghurt because it had only two observations. Except for porridge, the rest of the food items confirm that the quantity of plate waste is closely linked to the amount of food served (Ferreira et al., 2013). In the case of breakfast porridge, high waste percentage is likely if the student for unknown reasons served the porridge but did not consume it at all. For example students are unlikely to consume porridge that is burnt or stale.

Taken as a whole, significant statistical differences (p=0.0258) in mean waste existed among food items consumed during breakfast in the second study (Figure 4.2). Significant differences in waste occurred between vegetables and salads and cereals, eggs and yoghurt. The least significant difference occurred between bread and cheese. However, when porridge and yoghurt were excluded from analysis due to small number of observations, the differences in wastes between vegetables and salads and cereals and eggs persisted (figure 4.3). Again, the least significant difference was found between bread and cheese.

Lunch

During the first study's lunch, fruit registered the highest plate waste-99 percent, suggesting almost nil consumption (Table 4.5). Vegetables and salads had the highest number of observations and generated a mean waste of 29 percent while custard generated 50 percent waste with 34 observations. Except for fruits and beef sausages, there was a general strong significant difference (p=0.0000) in wastage among the food items (Figure 4.4). However when fruit and beef sausages were excluded from analysis because of small number of observations, significance differences in waste persisted among various food items except between bread and custard (Figure 4.5).

During second study's lunch, bread recorded highest waste with 15 observations. This contrasts with 40 percent waste recorded from vegetables and salads yet they had the highest number of observations: 83 (Table 4.6). Potatoes had least waste value: 9 percent with 37 observations. Overall, the differences between food items wasted during this meal were statistically significant (p=0.0000) except between vegetables and salads and cake, chicken, fruits and beef mince (Figure 4.6).

Dinner

During the first study's dinner, fruits registered the greatest waste at 84 percent with a total of 4 observations (Table 4.8). Rice, with the highest number of observations: 48, followed with 59 percent while vegetables and salads with 35 observations registered a 30 percent waste.

Given that both rice and vegetables were served to almost similar number of students, the high waste in rice compared to vegetables may mean that for un-established reasons, rice was very unpopular among students during this meal of the day. On the whole, significant differences (P=0.000) in percentage waste was realised between food items during this meal. This difference existed between vegetables and salads and fruits, bread and rice. Figure 4.7 displays the differences in individual food items wasted during this meal.

During second study's dinner, bread registered the biggest waste: 65 percent with 13 observations while vegetables and salads recorded the least waste 27 percent yet it had the highest number of observations (66) (Table 4.9). Beef sausages with only 3 observations showed 60 percent waste. Similar to first round, an overall significant difference (P=0.00002) in waste existed among food items (Figure 4.8). Significant difference occurred between vegetables and salads and fruits, bread and beef sausages. Nonetheless, there was no significant difference in plate waste between vegetables and salads and macaroni. The greatest significant difference in waste existed between vegetables and salads and bread.

Limited data exist on quantity plate waste of specific food items in University dining facilities since different food items are prepared in these facilities (Whitehair et al., 2013; Al-domi et al., 2011; Babich and Smith, 2010; Sarjahani et al., 2009). However, previous studies have reported data on individual food items waste in various food service institutions. Nichols et al. (2002) surveyed a US community retirement living centre and reported that fats had the largest waste (31 percent) followed by vegetables (29 percent), meats (27 percent), starches (25 percent), milk (20 percent), fruits (12 percent) and desserts (11 percent). Cohen et al. (2013) reported that students of US National School Lunch Program waste 73 percent of vegetables, 47 percent of fruits, 25 percent of milk, and 19 percent of entrées whereas Williamson et al. (2003) analysed plate waste (using weighing method) in six different University cafeteria menus and reported that beverage had most waste (43.4 ± 2.13) followed by dessert (22.2 ± 19.87), fruit and vegetables (21.5 ± 1.18), entrée (15.8 ± 1), starch (14.7 ± 0.59) and condiments (4.7 ± 0.37).

Based on the results of previous studies, it can be argued that there is no clear pattern in individual items plate waste: different food items register different quantities of plate waste. This argument is consistent with the findings of the current study. For example, bread registered 47 percent plate waste during first study's lunch and 78 percent during second study's lunch. Buzby and Guthrie (2002) attributes the lack pattern in plate waste to differences in students energy requirements and appetites while Nichols et al. (2002) attributes it to differences in tastes and preferences. Overall, the current study's results agree with the findings of Ferreira et al. (2013) which showed that the quantity of food waste depends on the number of meals served. Results equally indicate that the amount of food consumed dictates plate waste. For example, porridge during second study's breakfast and fruit during first study's lunch generated highest waste yet they had the least number of observations.

4.3. Effects of gender

There were differences in the mean percentage plate waste between males and females. Overall, males showed a slightly higher mean plate waste (45.33 percent) than females (45.17 percent) (Table 4.12). However, the overall mean percentage plate waste between males and females were not statistically different (p=0.05). This implies that although more males (389) wasted food than females (337), statistically, no single gender wasted more food than the other. This finding agrees with that of Al-domi et al. (2011) who reported no significant difference between female and male students of University of Jordan as regards quantity of food items purchased and quantity of food plate waste. Therefore, the percentage differences in waste (in the current study) can be attributed to the fact that more males than females were served meals in this dining facility. As such, food plate waste reduction strategies should target all students irrespective of gender.

Table 4.12 Number, mean and range of student diners during each meal

	Breakfast				Lunch				Dinner			
	First study		Second study		First study		Second study		First study		Second study	
	N	Mean (range)	N	Mean (range)	N	Mean (range)	N	Mean (range)	N	Mean (range)	N	Mean (range)
Male	32	50(32-68)	19	47(25-68)	110	49(40-58)	96	41(34-48)	70	43(35-51)	62	41(33-49)
Female	26	42(24-61)	17	40(16-63)	83	50(50-60)	94	38(31-45)	65	53(45-61)	52	49(41-58)

N=Number of student diners

4.4. Cost of plate waste

During the two studies, the cost of plate waste averaged to R480.78 per day (R529.02 and R432.54 during first and second studies, respectively) (Tables 4.15 and 4.16). The average cost of plate waste stood at R2.56 and R1.07 for students who left plate waste and the entire dining facility, respectively (Tables 4.13 and 4.14). The greatest financial cost of food waste was found during lunch followed by dinner and then breakfast. Coincidentally, the highest quantity of food was served during the lunches, followed by dinners and finally breakfast. This suggests that the financial cost of plate waste depends on the quantity of food wasted which in turn depends on the quantity of food served.

There is very limited data on the cost of food plate waste around University settings which limits comparison of the current study's findings with previous ones. Cohen et al. (2013) found that middle school students waste 26.1 percent of the total food budget while Buzby and Guthrie (2002) reported that 12 percent of government expenditure on the National School Lunch Program is wasted. The current study's finding of R480.78 per day translates to approximately R58 655.16 per University academic semester and R117 310.32 per year for Metanoia residence hall alone. However, in reality, the overall socio-economic and environmental cost of plate waste will be larger that these figures. It is worth noting that these figures were computed using *only* the retail prices of food items that were wasted: the prices do not include transport, energy and labour costs associated with final prepared food. Furthermore, additional costs are incurred to haul the food waste to landfills where environmental degradation costs are also incurred. Kitzes et al. (2007) showed that fossil fuel

energy employed in growing, processing, packaging, transporting and preparing food increases global carbon footprint and speeds up global warming. Also, while the daily average cost of plate waste from this study may appear small, Heller and Keoleian (2003) demonstrated that saving one food calorie creates a sevenfold energy savings across the food life cycle. Moreover, given that an average food item travels an average of 1500 miles before reaching the final consumer, every gram of food saved from waste contributes to reduction of agricultural environmental footprint (Pirog and Benjamin, 2003).

Table 4.13 Average cost of plate waste during first study (6/5/2014)

	Cost of FPW (Rands)	Total number of students (with FPW)	Total number of students (entire dining facility)	Cost per student (with FPW) Rands/student	Cost per student (entire dining facility) Rands/student
Breakfast	85.05	24	49	3.54	1.74
Lunch	244.9	90	164	2.72	1.49
Dinner	199.07	68	193	2.93	1.03
Total	529.02	182	406	2.91	1.3

Table 4.14 Average cost of plate waste during second study (21/5/2014)

	Cost of FPW (Rands)	Total number of students (with FPW)	Total number of students (entire dining facility)	Cost per student (with FPW) Rands/student	Cost per student (entire dining facility) Rands/student
Breakfast	52.84	15	40	3.52	1.32
Lunch	236.03	108	253	2.19	0.93
Dinner	143.67	73	225	1.97	0.64
Total	432.54	196	518	2.21	0.84
Average cost of plate waste (for the two studies)				2.56	1.07

Table 4.15 Cost of plate waste. First study (06/5/2014)

Food items	Breakfast Amount of FPW (Grams)	Breakfast Price per gram (R/grams)	Breakfast Cost of FPW (Rands)	Lunch Amount of FPW (Grams)	Lunch Price per gram (R/grams)	Lunch Cost of FPW (Rands)	Dinner Amount of FPW (Grams)	Dinner Price per gram (R/grams)	Dinner Cost of FPW (Rands)	
Fruit	190	0.01	1.71	172	0.01	2.41	554	0.01	4.98	
Vegetables	355	0.03	9.22	3797	0.03	98.67	1135	0.03	29.49	
Bread	314	0.02	5.44	1401	0.02	24.29	295	0.02	5.11	
Cereal	500	0.06	29.99							
Cheese	11	0.09	1.02							
Beef sausages	273	0.06	17.74	58	0.06	3.77	261	0.06	16.96	
Yoghurt	439	0.03	13.52							
Eggs	219	0.03	6.40							
Spaghetti				1113	0.02	22.24				
Custard				2564	0.04	93.53				
Soup							939	0.05	43.41	
Macaroni							350	0.02	6.99	
Pizza crusts							679	0.01	9.02	
Rice							6396	0.01	83.10	
Total cost FPW (Rands)			85.05			244.90			199.07	529.02

Table 4.16 Cost of plate waste. Second study (21/5/2014)

Food items	Breakfast Amount of FPW (Grams)	Breakfast Price per gram (R/grams)	Breakfast Cost of FPW (Rands)	Lunch Amount of FPW (Grams)	Lunch Price per gram (R/grams)	Lunch Cost of FPW (Rands)	Dinner Amount of FPW (Grams)	Dinner Price per gram (R/grams)	Dinner Cost of FPW (Rands)	
Fruits				154	0.01	2.15	440	0.01	3.96	
Vegetables	316	0.03	8.21	6500	0.03	168.90	3435	0.03	89.26	
Bread	174	0.02	3.02	807	0.02	13.99	600	0.02	10.40	
Cereals	157	0.06	9.42							
porridge	22	0.02	0.47							
cheese	277	0.09	25.6							
Eggs	193	0.03	5.64							
Yoghurt	15	0.03	0.46							
Cake				1693	0.01	22.92				
Potatoes				456	0.01	2.50	0	0.01	0	
Chicken				240	0.03	7.92	0	0.03	0	
Beef Mince				210	0.08	17.64				
Beef sausages							150	0.06	9.75	
Macaroni							1517	0.02	30.31	
Total cost of plate waste (Rands)			52.84			236.03			143.67	432.54

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4.5. Results of questionnaire on food plate waste

4.5.1. Frequency of wasting edible food

During the first study, a total of 140 students responded to this question and 28 percent (n=39) reported they occasionally leave food on their plates after their meals (Figure 4.10). A further 23 percent (n=33) and 10 percent (n=14) indicated that they very frequently and always, respectively, leave food after eating, while 12 percent (n=17) and 18 percent (n=25) rarely or very rarely, respectively, often leave food. Nine percent (n=12) of respondents stated that they never leave food on their plates.

During the second study, 132 student responses were documented, of which 27 percent (n=36) indicated that they 'occasionally' leave plate waste. Additionally, 17 percent (n= 22) and 14 percent (n=18) designated that they very frequently and always, respectively, often leave food on their plates. Further on, 15 percent (n=20) and 19 percent (n=26) denoted they rarely or very rarely, respectively, leave food while 7 percent (n=10) of respondents stated they never leave any portion of their meals.

The results of the mean, mode and inter-quartile range (IQR) (Table 4.17) of this question show that the majority of respondents occasionally left food on their plates. Also, the large IQR value suggests a huge division among the respondents who chose the two extremes i.e. 'always' and 'never' leave food.

Table 4.17 Plate waste Likert scale mode, mean and interquartile range

	How often do you leave food?		Overall meal rating?		Do you like the menus?		Do you think plate waste is a problem?		Rate your awareness on food waste as a problem		How often do you book meals and never show up to eat?	
Round	First round	Second round	First round	Second round	First round	Second round	First round	Second round	First round	Second round	First round	Second round
Mode	4	4	3	4	4	4	4	4	3	3	2	2
Median	4	4	3	4	3	3	4	4	3	3	2	2
IQR	3	3	1	1	1.5	1.25	1	1	2	2	2	2

Table 4.18 Plate waste Likert scale spearman correlations and p-values

Paired Questions	How often do you leave food & Overall meal rating?		How often do you leave food & Do you like the food menus?		How often do you leave food & Do you think plate waste is a problem?		How often do you leave food & Awareness of plate waste as a problem		How often do you leave food & How often do you book meals but never show up to eat	
Date	First round	Second round	First round	Second round	First round	Second round	First round	Second round	First round	Second round
Spearman R	-0.248174	-0.058753	-0.21728	-0.184567	0.009113	0.070509	0.063413	-0.055267	0.117708	0.315871
P Value	0.003455	0.503382	0.010191	0.034126	0.915829	0.423551	0.464973	0.532281	0.172324	0.000238

A literature review revealed that very few studies have evaluated food plate specific aspects such as how often diners leave edible food portions. Collison and Colwill (1987) reported that 31.35 percent (280 out of 893) of diners in UK public houses and diners usually leave edible portions when they eat out of home. This finding is comparable to 28 percent (on average) of

diners in the current study who indicated that they occasionally leave food portions, suggesting close resemblance of frequency of leaving food portions in these two populations.
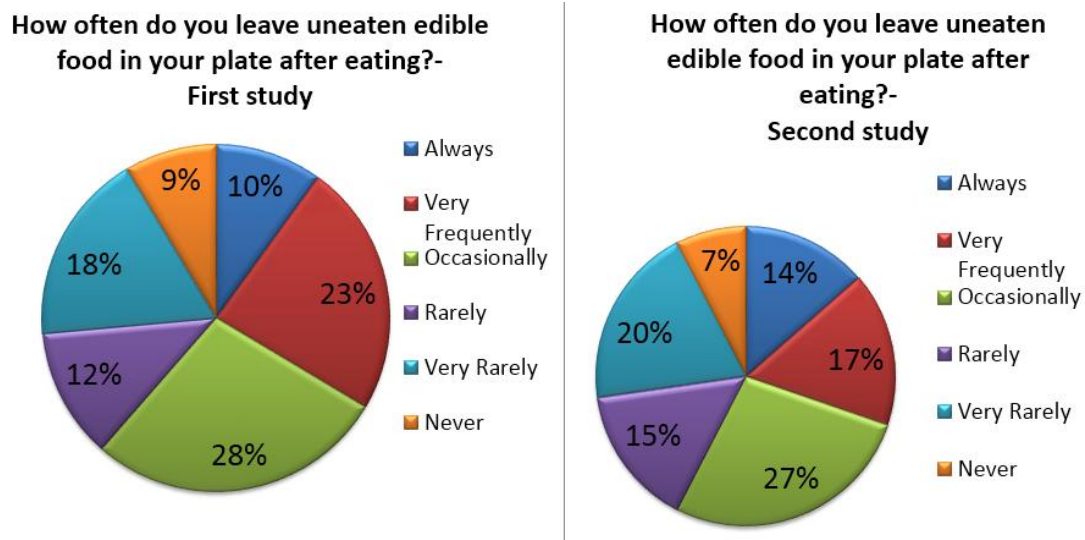

Figure 4.10 How often students leave plate waste

4.5.2. Reasons for food plate waste

Why do you leave meals on your plate?

A total of 140 and 132 students responded to this question during first and second studies, respectively. Inappropriate food taste was reported by 75 percent (n=105) and 77 percent (n=102) on first and second studies, respectively (Figure 4.11). During the first study, 34 percent (n=47) and 22 percent (n=31) indicated inappropriate food appearance and 'not hungry', respectively while on the second study, 23 percent (n=30) and 34 percent (n=45), respectively, cited similar reasons. Inappropriate temperature was specified by 25 percent (n=35) and 21 percent (n=29) during first and second studies, respectively. Likewise, the large portion size and inadequate time to eat were cited by same number of students 16.43 percent (n=23) on the first study, and 12.88 percent (n=17) and 9.85 (n=13) students, respectively on the second study. Other reasons cited during the first study was that food the food was culturally unacceptable (5 percent, n=7) and dental problems (2.14 percent (n=3). During the second study these factors were mentioned by 3.79 percent (n=5) and 3.03 percent (n=4) correspondingly. Figure 4.2 presents these data.
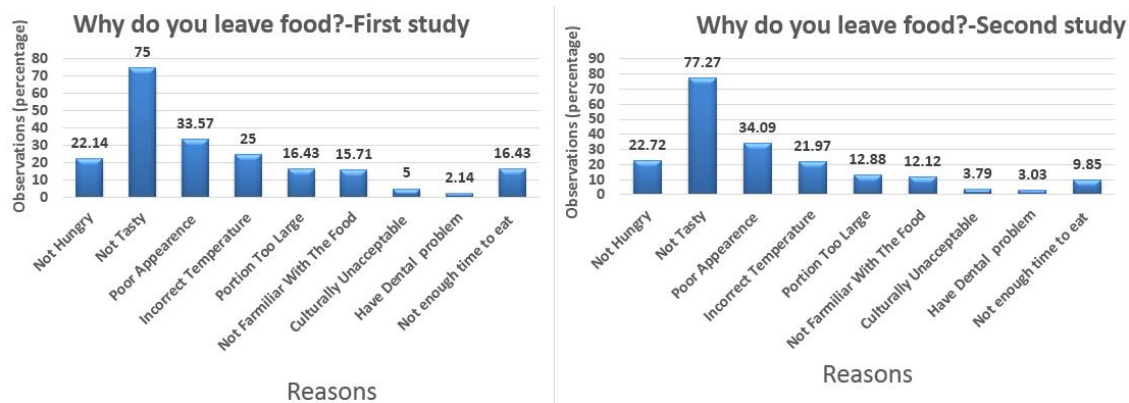
Figure 4.11 Reasons for plate waste

A close interrogation of data reveals that 40 percent (on average) of respondents who cited poor food taste as a reason for leaving plate waste also specified poor food appearance. Similarly, 28 percent of students who indicated food 'not tasty' as reason for not finishing their meals also cited poor appearance of food. These data show that that poor food taste is the single largest cause of plate waste in this dining facility. This is followed by inappropriate appearance and temperature, in that order. This means that the greatest cause of food plate waste in this dining facility relates to food quality and presentation aspects. This finding concurs with those by Kelly (1999) and Díaz and García (2013) who showed that good food taste and optimum serving temperature raises meal acceptability and consumption, hence lowering plate waste. While the impacts of appearance and temperature as factors that influence plate have been investigated mainly around hospital settings (Huls, 1997; William and Walton, 2011) and restaurants (Engström and Carlsson-Kanyama, 2004; Collison and Colwill, 1986), the current study's data reveal that these factors equally influence the quantity of food generated in university dining facilities.

Equally, 'not hungry' was indicated as reason for food waste. While there may be various reasons for this, a modest explanation is that students typically eat from other competing food stores (or elsewhere) before they proceed to the dining hall (Bergman et al., 2004). In Metanoia dining facility, students book meals at least 48 hours before the actual eating time. As such, it is likely that students who eat from elsewhere but still turn up to eat the meals they booked in advance will rate food portions as large. Furthermore, a combination of large food portions and 'not being hungry' can significantly raise food plate waste quantities. Current study's data shows that 28 percent an (on average) of the respondents who cited 'not hungry' also marked large food portions as reasons for leaving plate waste. On the other hand, individuals rate food portions differently depending on how much food they usually eat or how hungry they are at the eating time: the same food portion may be rated as big or small by various individuals.

Hong and Kirk (1995) assessed plate waste in 11 hospitals and established that 19 percent of the patients waste food because they are served in extremely large portions. This figure is slightly different from the 15 percent (on average) established in the current study. However, this difference can be attributed to the fact that, due to disease, hospital patients' undergo physical and physiological changes that reduces their eating appetite while encouraging plate waste. Nevertheless, this study together with those by Vermeer et al. (2011), Freedman, (2011); Collison and Colwill, (1987) show that smaller portion sizes discourage plate waste.

13 percent (on average) of respondents of the current study indicated that they don't complete their meals due to inadequate eating time. This figure is significantly lower than 34 percent established by Bergman et al. (2004) who showed a 16.3 percent reduction in plate waste when lunch period was extended by only 10 minutes. Nevertheless, both figures underscore the importance of adequate eating time in lowering plate waste. While Bergman and colleagues carried out their study in a primary school, their findings can be applied to a University dining facility since both are learning environments that operate under strict timetables.

Finally, students cited a lack of familiarity with the food items they book and serve as a reason for plate waste. This finding agrees with the contention by Engström and Carlsson-Kanyama (2004) that the amount of food wasted in a school depends on students familiarity with the food items prepared and served. Presumably, prior knowledge of food improves the relationship between the consumer and its food. Good relationship increases consumption while simultaneously lowering plate waste (Ferreira et al., 2013).

4.5.3. Satisfaction with meals and menus and frequency of eating booked meals

How would you rate the meal you just had?

On average, 99 percent of respondents' attempted this question during the two studies. During the first study, 57 percent (n=78) rated their meals as satisfactory while during the second study, 38 percent (n=49) indicated similar choice (Figure 4.13). A further 29 percent (n=40) indicated their meals as good and 7 percent (n=10) as poor, respectively on the first study. 40 percent (n=52) and 8 percent (n=11) marked the same options correspondingly on the second study. Finally, on the first study, 5 percent (n=7) rated their meals as especially good, and 2 percent (n=2) as especially poor. The same choices were indicated by 15 percent (n=20) and 0 percent (n=0) respectively on the second study.

A trend is evident in these data. The mode and median values (Table 4.17) indicate that most students rated their meals as satisfactory on the first study, and on the second study as good. An interquartile range of 1 in both cases suggests that there was a general agreement (i.e. no difference in opinions) as regards the food quality. The overall rating of meals as 'satisfactory' and 'good' implies general satisfaction with meals. Satisfaction has been used as a sign of meal acceptability (Hartwell et al., 2006). However, consumer satisfaction with food is not a universal phenomenon and is thought to be in the mind: different students may derive different degrees of satisfaction from the same meals or food items (Hartwell et al., 2006). Moreover, food acceptability and satisfaction depend on both food attributes and people's expectations of what the food should be (Meiselman, 2003). Positive expectations results into high food rating while a gap between expected and actual food quality i.e. disappointment may result into a severe down-rate of food, beyond the actual quality (Hartwell et al., 2006).

While the above explanation may account for students who rated their meals as poor, it may account for those who rated their meal as satisfactory as well. In other words, while studies (Hartwell et al., 2006) show food quality as the most crucial factor for satisfaction, factors such as ambience of the eating environment, receptiveness of catering staff etc., play crucial roles (Huls, 1997). Furthermore, overall food rating cannot be used *solely* as a measure of food quality: while diners may rate the meal as good, they may dislike other specific meal aspects,

for example, the level of food seasoning. Even so, minimal plate waste is likely to be generated from highly satisfying food (or highly rated for that matter). In the current study, the significantly strong negative correlation during the first round (r_s=-0.2482, p=0.0036) between how often students leave food and overall meal rating is valid: students who rate food/meals as poor are likely not to complete those food/meals.
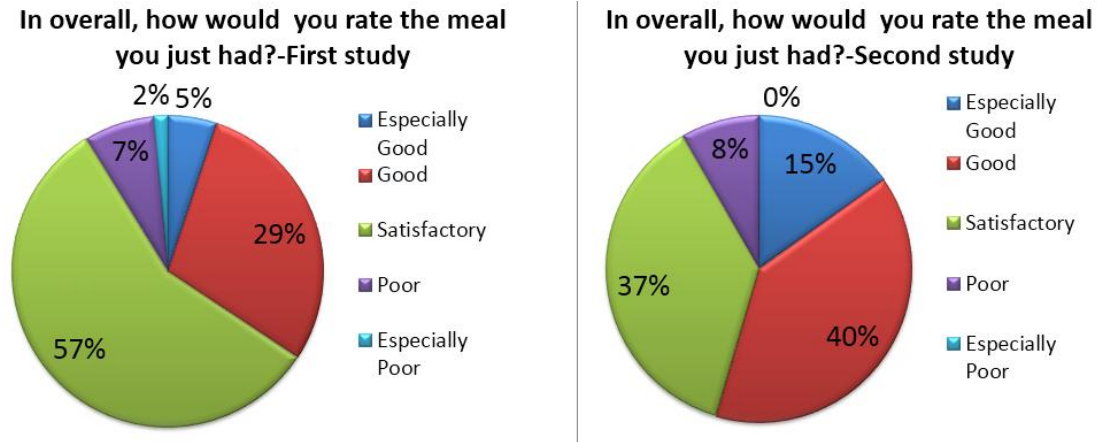

In overall, how would you rate the meal you just had?-First study

- Especially Good
- Good
- Satisfactory
- Poor
- Especially Poor

2% 5%
7%
29%
57%

In overall, how would you rate the meal you just had?-Second study

- Especially Good
- Good
- Satisfactory
- Poor
- Especially Poor

0%
8%
15%
37%
40%

Figure 4.12 Overall rating of meals

Do you like the food menus being used in the dining facility?

A total of 139 and 132 students responded to this question during the first and second studies, correspondingly. 41 percent (n=59) indicated to 'a fair amount' and 29 percent (n=40) as 'a little' on the first study while 47 percent (n=62) and 26 percent (n=34) marked these choices respectively, on the second study (figure 4.12). Still on the first study, 21 percent (n=30) indicated 'not very much' while 5 percent (n=7) marked 'to a great deal', whereas on the second study, 21 percent (n=28) and 2 percent (n=3), respectively, marked these choices. During both studies, 4 percent stated they don't like the menus at all.

These results show that the menus are moderately popular, i.e. to 'a little' extent (median=3, interquartile range=1.5 and median=3, interquartile range=1.25 on the first and second studies respectively). All the same, the interquartile range value suggests that there was a slight difference in respondents' opinion i.e. between those who completely like them and who do not.

These results insinuate that the food menus adopted in the dining facility are moderately popular as they are liked by most students. Strong and significant negative correlations (r_s=-0.2173, p=0.0102 and r_s=-0.184567, p=0.03412-on the first and second rounds respectively) existed between questions on how often students leave their food and how much they like the menus. This seems to make sense i.e. the more students do not like the menus, the more they will 'often' leave food on their plates. This finding goes along with that of Martha et al. (2005) who found that lack of knowledge on students' food tastes and preferences, poor menu popularity and/or acceptance increases plate waste in school settings. Ultimately, a more popular menu-one that is accepted by most diners'-increases consumer satisfaction and in so doing generates less plate waste than a less popular one.
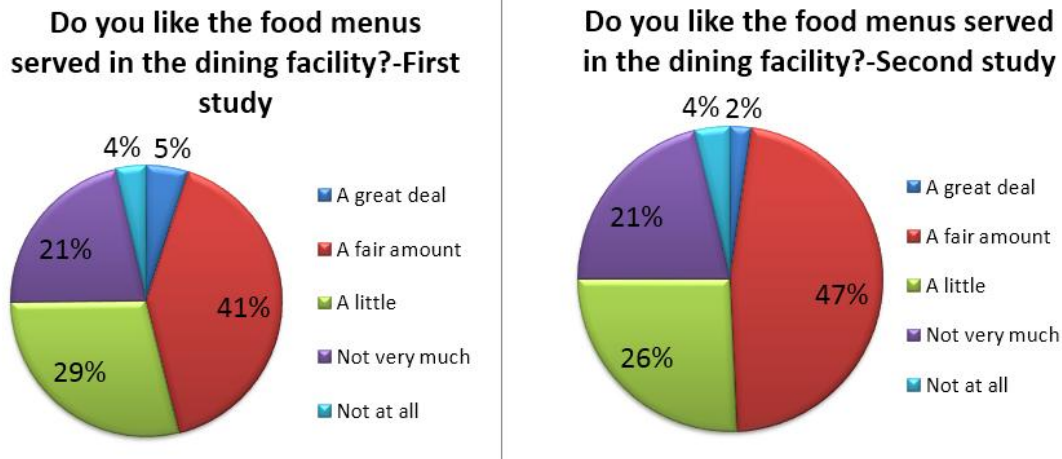
Figure 4.13 Menu popularity

How often do you book meals but never show up to eat?

To this question, majority indicated 'very rarely': 43 percent (n=59) and 35 percent (n=46) on the first and second studies respectively (Figure 4.14). 6 percent (n=8) and 3 percent (n=4) indicated they very frequently don't show up on the two studies, one-to-one while 19 percent (n=26) and 20 (n=26) percent said they occasionally do not turn up to eat their meals on the first and second study respectively. Another 11 percent (n=15) and 20 percent (=26) said, on the first and second studies respectively, they rarely book meals and fail to turn up to eat. 16 percent (n=21) and 17 percent (n=22) indicated that they book meals and always show up to eat while 5 percent (n=8 and n=7 on the first and second studies respectively) indicated that they do not show up always.

Based on these results, it can be concluded that most students book meals and show up to eat on a regular basis (median=2, interquartile range=2). Even so, the interquartile range value shows that respondents had widely opposing opinions on this question. While majority indicated 'very rarely', almost equal number of responses were captured from the two extremes i.e. those who always show up to eat and those who never show up completely.

Different reasons make student diners skip eating meals they pre-booked. These include: buying food from shops operating within the learning environment which means that diners remain full and cannot eat the meals they booked in prior (Bark, 1998); inconvenient scheduling for example some diners may have to attend classes during the meal time (Getlinger et al., 1996), diners negative attitude with regard to the quality of meal prepared (Hartwell et al., 2006), poor meal service, sanitation, and dining environment (Joung et al., 2011). A close examination of the reasons discussed in this paragraph reveal a similarity with the reasons for wasting edible food portions discussed earlier in this thesis, which suggests that addressing the reasons for wasting food will reduce, in part, the chances of diners skipping meals they booked in prior. While the current study established that majority of diners regularly skip meals, it did not determine the specific reasons for this, a gap that could be filled by future research.
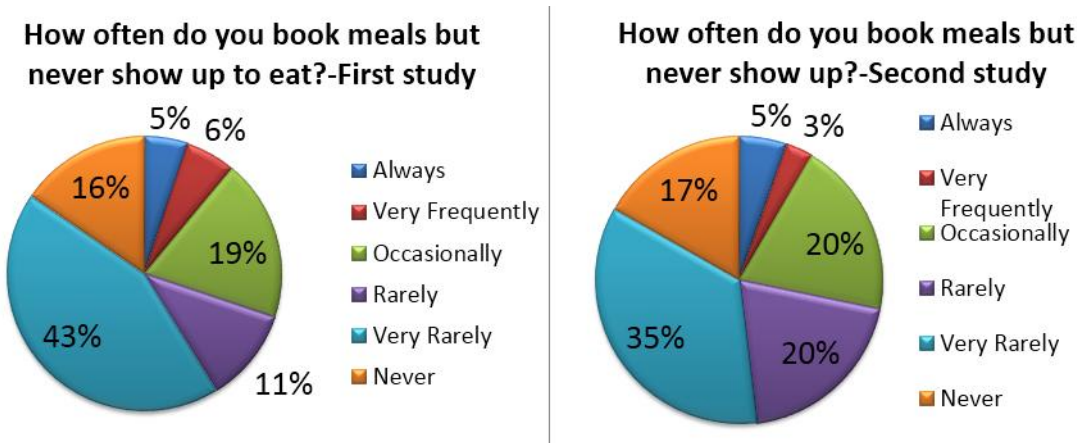
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Figure 4.14 Frequency of showing up to eat booked meals

4.5.4. Food waste as a problem and awareness among students

Do you think food waste is a problem in the dining halls?

Students gave different responses to this question. On the first study, 36 percent (n=49) of the 137 students who responded to this question stated that food waste is a great problem whereas on the second study, 35 percent (n=46) out of 131 specified the same choice (Figure 4.15). Further, on the first study, 23 percent (n=32) indicated that food waste is a very great problem while 20 percent (n=26) marked similar choice during the second study. However, 6 percent (n=9) and 1 percent (n=1) specified that food waste is little problem during the first and second studies, respectively.

Again, these results imply that a greater part of students perceive food waste as a problem within the hostels (median=4, interquartile range=1). This is underscored by the small interquartile range value which depicts little differences in opinions as regards food waste being a problem in the dining hall.
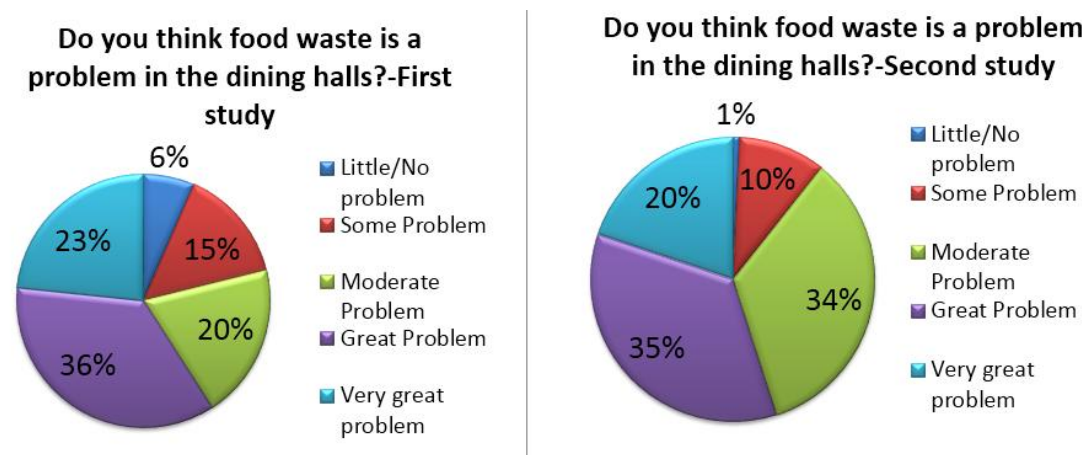

Figure 4.15 Students' thought of food waste as a problem

How would you rate your awareness about food waste as a problem?

135 and 130 participants rated their awareness concerning food waste as a problem during first and second studies respectively. 29 percent (n=39) and 27 percent (n=35) indicated their awareness as moderate, on the first and second studies respectively (Figure 4.16). On both studies, 27 percent indicated their awareness as slight. Further on, 28 percent (n=38) and 23 percent (n=30) stated that they are 'very aware' on the first and second studies respectively. 7 percent (n=10) and 10 percent (n=13) said they are 'extremely aware', during the first and second studies respectively. Lastly, 9 percent (n=12) and 13 percent (n=17) indicated they are completely unaware, during the first and second studies correspondingly.
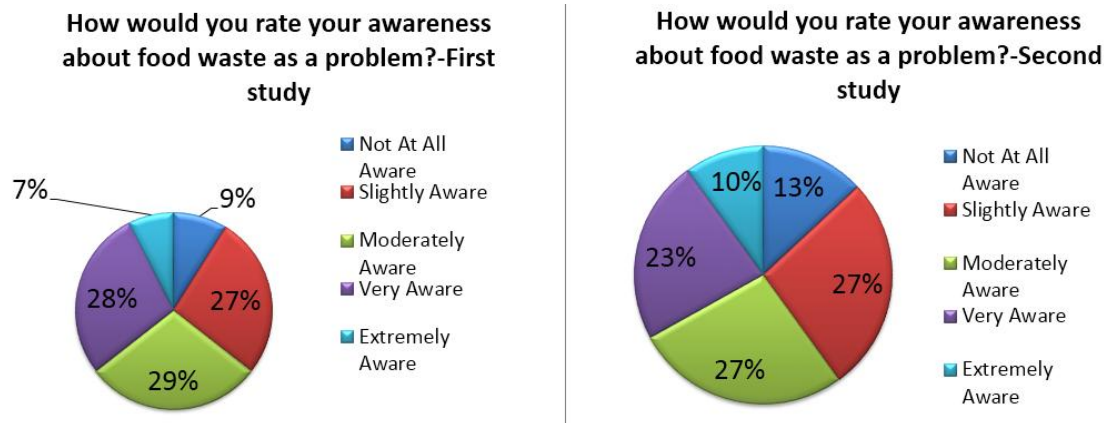

Figure 4.16 Students' awareness of food waste as a problem

These results indicate that food waste awareness among most students is moderate (median=3, interquartile range=2). Nonetheless, the big interquartile range value indicates significant variation in awareness between the two poles of the divide i.e. extreme awareness and no awareness. These results are comparable to that of Desa et al. (2011) who reported moderate knowledge and awareness concerning solid waste management (including plate waste) among 589 first year students in a Malaysian University.

A close examination of these results indicate that majority of students (>75 percent) think that food plate waste is a problem within the dining facility. Likewise, about 89 percent (on average) of students stated that they are aware food waste is a problem in the dining facility. When interpreted together, these results indicate presence of general awareness of food plate waste as a problem within the student body. However, quite the reverse, when summed up, 60 percent of the total number of respondents indicated that they occasionally, very frequently or always leave plate waste. Similarly, overall, 39 percent of respondents indicated that they book meals but never show up to eat always, very frequently or occasionally.

These results are intriguing: while general awareness of food waste as a problem exists, it is not translated into conduct or action. That is, while students have knowledge and awareness that food plate waste causes socio-economic and environmental problems, they do not act to reduce plate waste so as to reduce these problems. A significant number students often leave plate waste. Also, a number of students book meals but never show up to eat, remember booking meals and not turning up to eat may as well mean discarding the whole volume of freshly prepared and served food. Equally, it is logical that students should not leave any food plate waste if they are aware of the negative consequences of doing that. In summary, these

data invalidate the general perception that by just being aware, students' can change their attitudes, behaviours and actions as concerns food waste: students have to be reminded to act in ways that reflect their awareness and beliefs.

A study by Whitehair et al. (2013) found comparable results which showed that while students hold key sustainability beliefs, they do not act in ways that reflect such beliefs. Furthermore, the study found an increased and sustained positive change of students' behaviour as a result of education programmes. These programmes reminded students to exercise their positive beliefs while in the dining facility. Therefore, providing information on the consequences of food waste to students without knowledge can significantly reduce food waste quantities generated in students dining facilities. Nonetheless, to those with the knowledge, regular information that serves as reminders is crucial.

4.6. Summary and conclusions

The current research assessed food plate waste in a University dining facility on two occasions (studies). 41 percent of the diners who were served food left edible food portions on their plates. During the two separate studies, lunch had the largest quantity of plate waste (19.17 kg) and attendance (198) followed by dinner (16.75 kg and attendance 141) and breakfast (3.46 kg and attendance 39). Interestingly, lunch had the smallest value of mean percentage plate waste (36 percent), followed dinner (40 percent) and breakfast (45 percent), suggesting that the quantity of plate waste depends on the quantity of meals served and the specific food quantity defined. Plate waste minimisation strategies should pay special attention to breakfast due to the apparent low turnout and high quantity of food plate waste since a high number of meal booking but low attendance may increase the quantity of plate waste.

An analysis of mean plate waste was done at two levels, i.e. among only the student diners who left edible food portions and for the entire group of diners who ate from this dining facility, and the results showed that mean plate food waste was 40.42 ± 2.05 and 6.35 ± 1.25 percent per day for the former and the latter, respectively. Judging from previous studies, the current study's entire dining facility mean plate waste may be considered acceptable while that among diners who left edible food portions as unacceptable. While previous studies have mainly presented mean plate waste for entire group of diners, a two-level analysis permits assessment of the level of intensity of plate waste within students who leave plate waste as well as the entire group of diners. This eliminates the typical underestimation when only plate waste of the whole dining facility is assessed.

There were no significant statistical differences in mean plate waste between males and females, which suggested that plate waste reduction measures in this dining facility should target all students irrespective of gender.

The various food items had equal chances of being discarded hence were wasted in varying quantities. However, compared to other food items, vegetables and salads and bread were served during each meal, hence registered largest mean plate waste. Data shows that the amount of food wasted depends on the food quantity consumed which in turn depends on diner's appetites, energy requirements, tastes and preferences.

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The cost of plate waste averaged to R480.78 per day. Meals which had largest quantity of plate waste showed the greatest cost suggesting that the financial cost of plate waste depends on the quantity of food wasted which in turn depends on the quantity of food served. While a cost of R480.78 per day may appear negligible, the real cost of 19.69 kg per day of plate waste generated in the current study is larger when the associated hidden economic and environmental costs incurred are considered, including transportation, energy, water, labour, land fill, pollution and greenhouse gases emissions associated with food waste.

Results show that majority of student diners in this dining facility occasionally left edible food portions on their plates. Poor food taste was the single largest cause of plate waste followed by inappropriate appearance, inappropriate temperature, large food portions and students not being hungry. This suggests that the greatest potential to minimise plate waste in this dining facility requires improvement in food quality and presentation. However, tailoring food portions to meet students' ever changing appetites and energy requirements and allowing them more eating time to will go a long way to reduce quantity of plate waste.

While the menus used in this dining facility were 'a little' popular, majority of the diners rated their meals as either satisfactory or good implying general satisfaction. Satisfaction has been used as a sign of meal acceptability. At the same time, majority of students stated that they occasionally leave edible food portions on their plate, meaning that overall rating cannot be solely used to determine clients' satisfaction with meals. Additional specific factors such as ambience of the eating environment and receptiveness of catering staff, among others play significant roles. Even so, minimal plate waste is likely to be generated by popular menus and meals rated as highly satisfying.

A close examination of current study findings indicated that majority of students (>75 percent) perceived food plate waste as a problem while 89 percent stated that they are aware that food waste is a problem within the dining facility. This suggests general awareness (within the students' body) of food waste as a problem, but which is not translated into conduct or action: students occasionally leave plate waste while others book meals but never show up to eat. Reducing plate waste requires providing information on the consequences of food waste to students without knowledge. Similarly, students who already have knowledge and positive beliefs as regards plate waste should be regularly reminded to act in line with those beliefs.

Chapter 5 - Study implications and recommendations

5.1. Food waste and minimisation measures

Food availability is crucial for every form of human civilisation. However, the current food production system is threatened by perpetual increase in human population, climate change, declining soil fertility, shortages of natural resources and growing costs of agricultural inputs notably fossil fuel-based fertilisers. While extensive resources (genetic modification, better farming methods, improved agricultural disease control chemicals) are being invested to improve food security, millions of human beings are still undernourished.

These happen against a setting wherein food production uses huge portions of the planet's limited natural resources and creates an ecological footprint that is too large and threatens sustainability of the very planet. Yet, agriculture must not only avail food for consumption but also improve farmers' social and economic wellbeing. Accordingly, it is imperative that food that is already produced is handled efficiently. Minimising food losses and wastes is a practical way to create such efficiency, thus improving global food situation.

It is estimated that between 30-50 percent of annual food global production is lost and wasted in the food supply chain. Of this, consumer food waste is the largest, chiefly due to ease of accessibility of food, desire by actors along the food supply chain to make more profits and poor infrastructure and management. Trends within the consumer food service industry indicate that while other types of food waste are reducing, plate waste is steadily increasing. This is despite costs associated with food waste disposal such as labour and haul charges. While sales volumes indicate that the food service industry has been growing, reduction and management of food waste has increased operations cost, thus threatening this growth.

In University dining facilities, plate waste is influenced by policies and practices that dictate food menus, food preparation and presentation (e.g. serving styles and flexibility of portion sizes) and larger environmental factors e.g. infrastructure constraints that may hamper plate waste minimisation. Availability of substitute foods from competing food sources within learning environments and consumers' behaviours and attitudes towards food also dictate quantity of plate waste.

Minimising plate waste in University dining halls requires adopting appropriate meal service systems, tailoring food portions to match individual students' appetites and energy needs, convenient scheduling of meals, improving menu variety, improving meal quality and acceptability, regulating size of eating bowls and engaging students in food waste minimisation strategies. Equally, regular plate waste auditing to characterise-in types and quantities-various food items discarded helps promotes plate waste source reduction and in planning for appropriate waste management. Providing information to both dining facility catering staff and students on the consequences, benefits and ways to reduce plate waste can stimulate change of behaviour for the better.

The current study investigated the extent, cost and reasons for food plate waste in a University dining hall. Students' attitudes to food such as the frequency with which they leave edible food items on their plates or book meals but never show up to dine were evaluated. Further, students' satisfaction with meals as regards meal menus, food quality, appearance and portion size were assessed. Equally, students' awareness and perception of food plate waste as a problem within the dining facility was assessed.

Overall, this information gives a glimpse into food plate waste dynamics in Metanoia and other dining facilities within Stellenbosch University that use similar catering system. Kwon et al. (2010) contend that, even though food waste is directly associated with increased cost of operations in foodservice institutions, food waste management is among the least investigated sustainability related themes. Furthermore, according to Oelofse and Nahman (2012), South Africa is in the process of making policies that enable waste (including food waste) management. Accordingly, an understanding of food plate waste magnitudes and composition in Universities dining facilities will positively augment the policy making process.

The 39 371 kilograms of plate waste generated over the two days of the current study should not be hauled to landfills, but instead be used to create valuable products. According to WRAP (2008), a single tonne of food waste is liable for 4.5 tonnes of carbon dioxide. Therefore, 39 371 kilograms of plate waste would produce approximately 177.17 kilograms of carbon dioxide. This figure translates to 10 807.37 kilograms of carbon dioxide per academic semester[3] and 21 614.74 kilograms of carbon dioxide in one academic year. So, Metanoia dining facility alone can reduce its contribution to global warming by avoiding emitting to the atmosphere 2.16 tonnes of carbon dioxide every year. Diverting the emission of 2.16 tonnes of carbon dioxide equals to removing from the road an average car (21 miles per gallon fuel economy) covering 328 miles (about 528 kilometres) per month i.e. approximately 17.6 kilometres per day (Bloch, 2014). Likewise, sequestration of 2.16 tonnes of carbon dioxide annually requires planting 11 trees every year (Bloch, 2014).

Avoiding such a huge amount of emission can be done in several ways. Firstly, the 39 371 kilograms of plate waste can be used to create fertilisers for organic farming by means of traditional composting or vermicomposting. However, while traditional composting is cheaper and easy maintain, the cost of running a vermicomposting centre is expensive and as such requires careful cost and benefit analysis prior to its institution (Babich and Smith, 2010).

Secondly, while not safe for recovery and redistribution to the needy, the 39 371 kilograms of food plate waste is sufficient to feed a modest number of farm animals, mainly poultry or pigs. While the dining facility does not engage in animal farming, it would significantly benefit for example by starting up poultry keeping as a result of reduced financial savings associated with purchasing poultry feeds. Nonetheless, on a positive note, Metanoia uses all generated food waste to make fertilisers through Bokashi technology (Swartz, 2014).

Overall, the current study's data demonstrates cultural similarity in wasting of more vegetables (compared to other food items) between South African consumers and consumers in other parts of world e.g. UK (WRAP, 2009) and Turkey (Pekcan, 2006). Culture has been shown to

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[3] One academic semester has approximately 122 days. Two academic semesters make one academic year

significantly influence the quantity of food waste (Stuart, 2009). Thus, future studies should identify cultural modifications that can work to limit food waste.

According to UK National Health Service Estates (NHSE) Hospitality (2005), the levels of food plate waste are deemed acceptable if endeavours to reduce them do not compromise food quality, consumers' choice, preferences and nutritional intake, or if costs associated with monitoring and/or addressing the waste surpasses the monetary worth of the waste. From the current study, it is unlikely that the cost of eliminating plate waste may exceed the financial value of the quantity of waste generated which stood at R 58 560.00 annually. While further detailed studies are required to determine the cost-benefits of reducing the FPW found in the present study, the socio-economic benefits will likely outweigh the investment costs required to reduce wastage. Whitehair et al. (2013) showed that simple messages developed by using *only* computers and printers and posted in the dining facility increases students' awareness or serves as reminders of the negative consequences of food waste and spurs positive change in behaviour. This is a financially feasible option available not only to Metanoia but also to other dining facilities within SU with identical type of operations.

Consumer behaviour has been indicated as the root cause of food wastage (Kantor et al., 1997). As regards the current dining facility, it is important that students develop awareness about how their food consumption patterns contribute to food waste and the subsequent economic and ecological consequences associated with such wastes. Accordingly, Metanoia's management and the University administration should be in the front line in championing the significance of reducing and eliminating food waste altogether. Furthermore, the University should prioritise educating and employing the student representative council (SRC) to publicise information on the benefits of, reasons for and how to participate in food waste reduction. For example, there is need to furnish students with regular statistics on the quantity of food plate waste generated from dining facilities. This will augment the fight against food waste by creating awareness and encouraging positive behaviour. A study by Kwon et al. (2010) assessed US University and college foodservice administrators' opinions of food waste minimisation activities. The study rated customers' education as most likely to way to reduce food waste, compared to adjusting portion sizes or changing menu planning.

While various methods to provide consumer education exist, in Metanoia, the following are feasible:

- Provision of waste prevention educational materials such as posters or pamphlets in the dining facility. These may function as reminders to students who already have the knowledge as well. Thus, information should be located strategically all over the dining facility. Also, information about the correlation between food waste and increased costs of operation may promote a positive change. Besides, increased operations costs certainly mean increased prices students pay for the meals.
- Metanoia dining facility should work closely with the campus waste management and recycling authority to execute and publicise food waste minimisation strategies. Ideally, students' opinions on food waste and possible reduction measures should be solicited.

Within Stellenbosch University, various communication channels for promoting food waste education exist. These include the campus radio station, campus newsletter, *Die Matie,* and the numerous student groups and house committees that operate in students' residential facilities. Equally, social media e.g. Facebook fun pages, twitter, Blogs, YouTube just to name a few,

can increase awareness and publicise information on food waste not only within dining facilities but also within the wider University.

Equally, the current study found that there is no examination of meals and/or food items consumption patterns within the dining facility. Babich and Smith (2010) argued that meal consumption patterns should inform meal preparation and serving quantities. This in addition to regular food plate waste audits will allow setting of achievable time bound food waste reduction targets. Also, regular food waste auditing will help in building awareness among both students and staff and in galvanising focused attention while simultaneously mobilising resources for reducing food waste (Lipsinki et al., 2013). Ultimately, reduction of plate waste among individual food items will be achieved. For example, Georgia Institute of Technology, one of the highest ranking Universities with sustainability practices in the US, achieved a 40 percent reduction in kitchen food waste from its dining facilities simply by instituting a waste tracking system (Georgia Institute of Technology, 2014).

While not investigated in the current study, statistics suggest that replacing trays with trayless dining reduces the amount of plate waste generated from University dining facilities (Sarjahani et al., 2009; Aramark Higher Education, 2008). Trayless dining reduces the food quantity that students may serve during one sitting. Essentially, trays can hold much higher number of plates (of food) at a time than would otherwise be held by hands. Thus, without trays, students are likely to serve and carry food quantities that they will eat. Ultimately, this reduces plate waste. Additionally, by limiting the amount of food served to students, the need to produce excessive quantities of food, which is known to increase quantities of kitchen left overs, is reduced. Further, eliminating trays will reduce the amount of water and energy and labour costs associated with cleaning these trays (Babich and Smith, 2010). Thus, further research to demonstrate the effectiveness of tray less dining as a viable option for reducing food plate waste in Metanoia is necessary.

The current study established that large food portion sizes promote plate waste. Accordingly, a need exists to tailor portion sizes to meet students ever fluctuating appetites and energy needs. In Metanoia, a straightforward way to do this is to reduce food items portion sizes. However, doing this may make students feel that they do not get the value of their money. Also, the revenues of FEDICS - the subcontracted catering company - may significantly decline if they begin to offer smaller food portions as that will imply charging less money. One way around these challenges is offer smaller food portions at lower prices while still offer larger portions at relatively high prices: a 'pay-by-weight-system'. In a 'pay-by-weight' system in which the weight of the food determines the cost of the food/meal, students get a strong economic incentive and do not serve more food than they need (Lipinski et al., 2013). Additionally, Engström and Carlsson-Kanyama (2004) indicated that plate waste is reduced when students are allowed to help themselves to the various food items in the presence of catering staff who may provide further assistance when necessary. Such system is attainable in the current dining facility. Nonetheless, while the latter system may be easy to adopt, the former requires initial capital to install, therefore, may take time to institutionalise.

Equally, in Metanoia, offering food samples for taste to students before booking or serving meals is a feasible option to lowering plate waste as students will be able to book food items they are familiar with and are likely to eat up. Engström and Carlsson-Kanyama (2004) showed that plate waste reduces when students have a prior knowledge of food items prepared in

school. Thus, providing detailed information on the specific food items prepared may increase familiarity with meals. Such information may be availed in the online meal booking system and should contain: the name of the dish/food item, nutritional content and preparation ingredients and methods. Information on food items may also be provided during consumer nutrition education sessions. Familiarity with food items will enable diners to look forward to consuming the food items/meals they book, thus reducing cases in which students book meals but never show up to dine.

With regard to food menus, Metanoia dining facility should consider carrying out periodic food preferences surveys among the students. Such surveys will indicate food items that are popular among students. This way, students will contribute to menu planning as their preferences will determine the food items purchased, prepared and served. Ultimately, this will increase menu popularity and reduce the quantity of food students discard.

The current study established that the total amount of time students are allowed to eat meals dictates the quantity of food plate waste. Therefore, basing on previous studies (Hartwell et al., 2006; Buergel et al., 2002; Getlinger et al., 1996) increasing dining periods may reduce plate waste and also promote better consumption of nutrients by students. During the investigation periods, it was found that Metanoia serves lunch meals (during weekdays) from 12.30 pm to 2.00 pm. This means that students who have to attend lectures from 1.00 pm have a period of only 30 minutes to consume their meals. Remember, this period includes the duration spent waiting in the service line. Buergel et al (2002) defines meal consumption time as the actual time one engages in food consumption. Without a doubt, 30 minutes must be considered inadequate and may encourage plate waste. Accordingly, Metanoia could consider starting lunch meal service from 12.00 pm to allow students at least one hour for meal consumption. However, rescheduling lunch periods would necessitate extra consultation between the dining facility and the University timetabling committee.

Relatedly, the current study established the poor food taste is the single largest cause of food plate waste in Metanoia. This finding agrees with those of Hartwell et al. (2006) who established that due to increased scale of production, offering quality and attractive meals while maintaining nutrition and food safety aspects is a great challenge to foodservice caterers. Kelly (1999) maintains that the only way around this challenge is adoption of better cooking and meal preservation methods. Accordingly, Metanoia should engage in culinary research to identify better cooking and food handling methods that would match its operations, catering population size and financial capability.

Ultimately, due to the complexity that characterise food waste, Metanoia could consider a more holistic approach. Waste reduction strategies should integrate the different divisions of the University, working as a team with the dining facility management and employees. For example, a waste prevention and management team that comprises the catering company, FEDICS, University waste recycling and management department and students through representation by the students representative council (SRC), can adopt, design and execute food waste reduction measures. While such a holistic approach will precisely fight against food waste, it will also create an environment that allows students to voice their opinions and concerns and eventually assist in making genuine sustainable changes.

5.2. Limitations and assumptions of the study

An interview with the kitchen manager revealed that while students book specific types of meals, some students change their minds at the point of meal service and do not take all the food items they had booked (which make up the meal plan they booked). This could have an effect on the amount of food served since this research used the number of meal bookings and plans (as provided by the kitchen manager) to compute the overall quantity of food served. Moreover, quantities of self-service food items may have been picked more than was booked. It was therefore not possible to determine if the exact quantities of food items that were booked were the ones that were actually served. Nonetheless, the number meal bookings were the soundest estimate to calculate the amount of food served.

Although the initial weight of food servings was used to calculate percentage plate waste, there were significant variations in these initial (servings) weights. Notably in food items such as chicken or fruits that were not served using standardised food serving equipment (e.g. serving spoons). However, as outlined in the methodology chapter, the average of three initial servings which was used to compute the initial quantity of food served was the best estimate.

Some students served meals and left the dining facility to eat from elsewhere. Also, during breakfast, students are also allowed a takeaway option. In both cases, it was not possible to determine the level of waste in food that left the dining hall.

While the current study assessed plate waste of food items that were booked and served by the central kitchen, some students ordered their meals from call order bars (located inside the dining facility) but ate from the dining facility. Since students returned their trays to the tray holder after eating, a mix up of plates from the central kitchen and the call order bars was possible. However, attempts were made to intercept trays from diners' to avoid possible mix up. Equally, the current study's method does not take into account food items that diners' may have traded, spilled or brought into the dining facility.

While drinks (liquids or beverages) may be significantly wasted, available resources could not permit their quantification during the current study. Future studies should examine the magnitude and dynamics of drink waste within Metanoia and other Stellenbosch University dining facilities.

Plate waste weight estimates reported in this study were obtained based on menu items that were served during the two separate studies representing two different days in a week and hence waste of the whole menu items served over a week was not examined. However, evaluation of the whole menu may not be possible since the dining facility adopts a seasonal cycle menu in which different food items are served during different days and seasons of the academic year. Thus, the two days estimate provided a reasonable glimpse into food plate waste dynamics of this dining facility.

Retail prices of food items change frequently. Therefore the cost of plate waste figure described in this study may only be valid for the specific day that the prices were obtained. However, this is satisfactory since current study aimed at providing only a cost estimate.

It is possible that some diners may have completed the food plate waste questionnaire more than once a day. To avoid this, before handing over a new questionnaire, students' were asked

if they had completed the questionnaire during the previous meal of the day. Only those who responded in the negative were allowed to complete a new questionnaire.

Lastly, the small sample size of this study restricts the generalisation of its findings to a wider population. Hence, current study's results are only estimates of food plate waste within the dining facility. A similar study in the future will help validate these findings.

5.3. Conclusions

The world's food system is at a crossroads. There is a need to increase food production to feed an exponentially growing human population. At the same time, factors such as declining soil fertility, climate change and the decline of natural resources, all put limits on both current and increased food production. Equally, it is acknowledged that agriculture's ecological footprint is too large and threatens the sustainability of the planet and must be reduced. It is against this background that there is a need to economically use food that is already produced by minimising food losses and waste.

Food service institutions operating within institutions of higher learning have unique opportunities to catalyse positive social change. This is in view of the number of students they serve and the unique roles of the institutions within which they operate, within modern society. As such, this task to graduate responsible and sustainability inclined students/citizens should be exploited to achieve sustainable development.

The results of this research show that while the overall plate waste for the entire dining facility is reasonably low, plate waste amongst diners who leave edible food is higher than is expected or is acceptable in a University dining environment. Accordingly, there is urgent need to adopt measures to reduce unnecessary plate waste. Among others, these measures include those that focus on improving meal quality especially meal taste, tailoring food portion sizes to match students' ever changing appetites and energy demands, offering food samples to raise familiarity with meals, performing regular food preference surveys and plate waste auditing to track levels of food consumption and waste and providing consumer education to change students behaviours for the better. Offering more palatable and healthy food items will increase food consumption while lowering plate waste. This will create significant cost-savings for the dining facility and students as well: students will most probably spend less money on buying food outside the dining facility. Crucially, the most effective food waste reduction and management measures are crafted through holistic approaches that integrate students, the dining facility and the broader University.

Owing to the fact food plate waste cannot be completely eliminated, available industrial and technological infrastructure can be used to create value out of food that is headed for waste. Animal feeds, soil fertilisers etc. can be created from such waste. Alternatively, plate waste can be directly fed to farm animals thus reducing the running costs of these farms. Still, as opposed to hauling to landfills where they have harmful ecological effects, perfectly food waste may be recovered and re-distributed to the poor/needy thus improving such peoples' food security levels.

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Appendices

Appendix A – Food Plate Waste Questionnaire

1. How often do you leave un-eaten edible food in your plate after eating?

	Please mark as X
Always	
Very frequently	
Occasionally	
Rarely	
Very rarely	
Never	

Why?

2. Why do you leave uneaten food? (Tick as many as possible).

	Please mark as X
Not hungry	
Food not tasty	
Don't like food appearance	
Food not served at the correct temperature	
Meal/food portion too large	
I am not familiar with the food/meal-haven't had it before	
Meal/food is culturally unacceptable	
I have problems with chewing/dentures	
I did not have enough time to eat and finish the meal	

Any other reason(s)?

3. Overall, do you think the food/meal you just had was? (Please tick one)

	Please mark as X
Especially good	
Good	
Satisfactory	
Poor	
Especially poor	

Why?

4. Do you like the menus (food options) that you book and get served in the dining hall?

	Please mark as X
A great deal	
A fair amount	
A little	
Not very much	
Not at all	

Why?

5. What type(s) of food do you waste mostly (Please tick one).

	Please mark as X
Fruits and Vegetables	
Meat and poultry (This category also includes Eggs, Milk, Cheese, Yoghurt).	
Cereals and Bread (This category also include Rice, potatoes, Pasta, Muffins).	

Any others?

     Why?

6. What type of meal/food (among those usually served) do you like most and you would like to be incorporated into the food menus?

Why?

7. Do you think food plate waste is a problem in the dining hall/halls of residence?

	Please mark as X
Little/No Problem	
Some Problem	
Moderate problem	
Great problem	
Very great problem	

     Why?

8. How would you rate your general awareness about food waste as a problem?

	Please mark as X
Not at all aware	
Slightly aware	
Moderately aware	
Very aware	
Extremely aware	

     Why?

9. How often do you book meals but never show up for eating?

	Please mark as X
Always	
Very frequently	
Occasionally	
Rarely	
Very rarely	
Never	

     Why?

10. What are your general thoughts on how food plate waste can be minimized in the dining hall?

Appendix B – Food Menus

Table B 1 Food menu. First study (06/05/2014)

	Meal plan	Standard meal	Vegetarian	Get balanced	Salad select	Better burger	Steak house	Lunch at dinner
Breakfast	Fruit juice	Fruit Juice	Fruit Juice					
	Cereal (4)	Cereal	Cereal	Muesli & Yoghurt Parfait				
	Main	Breakfast Scone	Breakfast Scone	Cheese and herb scone				
		Cheese	Cheese					
	Yoghurt	Yoghurt	Yoghurt	100 ml yoghurt				
	Fruit	Fruit	Fruit	1 whole fruit pp				
	Toast/ Bread	Bread	Bread	Bread				
	Spreads (4)	Jams/ Syrups/ Spreads	Jams/ Syrups/ Spreads	Jams/ Syrups/ Spreads				
	Tea/Coffee	Tea/Coffee	Tea/Coffee	150 ml milk pp				
Lunch	Fruit juice	Fruit Juice	Fruit Juice		Fruit Juice		Fruit Juice	
	Standard menu option	Cornish pie (mince)	Vegetable pie	Island Chicken with Pineapple & Ginger Sauce	Nuts-Apricot Chicken Pasta Salad		Prego Steak Rolls	
	Starch	Rice	Rice	Spaghetti			Chips/ Wedges	
	Vegetable 1	Steamed Butternut	Steamed Butternut	Gem Squash				
	Salad	Tomato & Onion salad	Pudding	Mixed Vegetables				
	Dessert	Baked vinegar pudding		Fresh fruit salad	Dessert of the Day		Dessert of the Day	
	Dessert sauce	Custard	Custard	Milk	Bread with Jams/ Syrups/ Spreads		Bread with Jams/ Syrups/ Spreads	
	Tea/Coffee	Tea/Coffee	Tea/Coffee	Tea/Coffee	Tea/Coffee		Tea/Coffee	
Dinner	Fruit juice	Fruit Juice	Fruit Juice		Fruit Juice	Fruit Juice		
	Yoghurt	Soup of the Day	Soup of the Day	Rice with lentils	Yoghurt & Fruit	Yoghurt		Melkkos/soup/hot chocolate/yoghurt
	Standard menu option	Pancake with creamy filling	Curried vegetable	Tender Beef Strips Tossed with Crunchy Vegetable Julienne & Sweet Chili-Soy Sauce	Honey & soy beef salad	Chicken Burger		Country Hot Pot; Samp; Balsamic Roasted beetroot
	Starch/ Veg	Green salad	Bread, Roti	Roasted beetroot		Chips		
	Veg / Salad	Fruit	Green salad	Tossed salad		Vegetables / Salad of the day		Dessert of the Day
	Fruit	Bread	Fruit	1 whole fruit per person		Fruit		Fruit
	Bread	Bread (4 slices pp)	Bread (4 slices pp)	Milk	Bread with Jams/ Syrups/ Spreads;	Bread with Jams/ Syrups/ Spreads &		Bread with Jams/ Syrups/ Spreads
	Spreads (4)	Jams/ Syrups/ Spreads	Jams/ Syrups/ Spreads	100 ml yoghurt				
	Tea/Coffee	Tea/Coffee	Tea/Coffee	Tea/Coffee	Tea/Coffee	Tea/Coffee		Tea/Coffee

Table B 2 Food menu. Second study (21/5/2014)

	Meal plan	Standard meal	Vegetarian	Get balanced	Salad select	Better burger	Steak house	Lunch at dinner
Breakfast	Fruit juice	Fruit Juice	Fruit Juice					
	Cereal	Maltabella / 3 x Cereal	Cereal	Muesli & Yoghurt Parfait				
	Main	Pizza Bagel	Breakfast Scone	Cheese and herb scone				
			Cheese					
	Yoghurt	Yoghurt	Yoghurt	100 ml yoghurt				
	Fruit	Fruit	Fruit	1 whole fruit pp				
	Toast/ Bread	Bread (4 slices per person)	Bread	Bread				
	Spreads	Jams/ Syrups/ Spreads	Jams/ Syrups/ Spreads	Jams/ Syrups/ Spreads				
	Tea/Coffee	Tea/Coffee	Tea/Coffee	150 ml milk pp				
Lunch	Fruit juice	Fruit Juice	Fruit Juice		Fruit Juice		Fruit Juice	
	Standard menu option	Southern Fried Chicken (leg 1/4)	Vegetable pie	Island Chicken with Pineapple & Ginger Sauce	Nuts-Apricot Chicken Pasta Salad		Prego Steak Rolls	
	Starch	Lentil Rice	Rice	Spaghetti			Chips/ Wedges	
	Vegetable 1	Roast Vegetables	Steamed Butternut	Gem Squash				
	Salad	Crunchy Garden Salad	Pudding	Mixed Vegetables				
	Dessert	Bread & Butter Pudding		Fresh fruit salad	Dessert of the Day		Dessert of the Day	
	Dessert sauce	Custard	Custard	Milk	Bread with Jams/ Syrups/ Spreads		Bread with Jams/ Syrups/ Spreads	
	Tea/Coffee	Tea/Coffee	Tea/Coffee	Tea/Coffee	Tea/Coffee		Tea/Coffee	
Dinner	Fruit juice		Fruit Juice		Fruit Juice	Fruit Juice		
	Yoghurt	Soup of the Day	Soup of the Day	Rice with lentils	Yoghurt & Fruit	Yoghurt		Melkkos/soup/hot chocolate/yoghurt
	Standard menu option	Pancake with creamy filling	Curried vegetable	Tender Beef Strips Tossed with Crunchy Vegetable Julienne & Sweet Chili-Soy Sauce	Honey & soy beef salad	Chicken Burger		Country Hot Pot; Samp; Balsamic Roasted beetroot
	Starch/ Vegetable	Green salad	Bread, Roti	Roasted beetroot		Chips		
	Vegetable/ Salad	Fruit	Green salad	Tossed salad		Vegetables / Salad of the day		Dessert of the Day
	Fruit	Bread	Fruit	1 whole fruit pp		Fruit		Fruit
	Bread	Bread (4 slices per person)	Bread (4 slices per person)	Milk	Bread with Jams/ Syrups/ Spreads.	Bread with Jams/ Syrups/ Spreads		Bread with Jams/ Syrups/ Spreads
	Spreads	Jams/ Syrups/ Spreads	Jams/ Syrups/ Spreads	100 ml yoghurt				
	Tea/Coffee	Tea/Coffee	Tea/Coffee	Tea/Coffee	Tea/Coffee	Tea/Coffee		Tea/Coffee