ABSTRACT

Title of Thesis: EXPLORATION OF THE FOOD WASTE ENVIRONMENT IN THE UNIVERSITY SETTING AND ITS IMPLICATIONS TOWARD A SUSTAINABLE FOOD SYSTEM

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Americans are throwing away an alarmingly high amount of food. As highlighted in this thesis project, a multitude of factors account for why food waste occurs, but also a significant potential exists for food waste reduction. The purpose of this research was to investigate the food waste environment in the university setting to better understand where to focus food waste reduction strategies. The volume of student plate waste was quantified, and the nutritional and environmental value of this plate waste was calculated. Further, a behavioral survey guided by the Theory of Planned Behavior helped to identify the key factors influencing food waste behaviors in this setting. Plate waste was found to be 5%-14% of all food served in the dining hall facility. The top three food groups that were most frequently discarded included starch and added sugars, fruits and vegetables and whole grains. Food waste related behaviors were found to be strongly influenced by having the confidence and skills for proper food management, feeling guilty about throwing food away, and having financial concerns related to food waste. The results of this research suggest that student plate waste is a significant problem with enormous potential for food waste reduction.

EXPLORATION OF THE FOOD WASTE ENVIRONMENT IN THE UNIVERSITY SETTING AND ITS IMPLICATIONS TOWARD A SUSTAINABLE FOOD SYSTEM

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Chapter 1: Introduction

1.1 Problem Statement & Rationale

In recent years, sustainability debates have focused on reduction of food loss and food waste as national evidence has shown enormous volumes of wasted food being generated and the resulting adverse social, financial, and environmental consequences. Wasted food represents a loss of essential nutrition, that could have been used otherwise to feed the nearly 1 billion individuals who are hungry and undernourished[1,2] as well as a loss of finite natural resources, such as water, land and energy that are invested into growing and cultivating food that is never eaten. Wasted food is also filling our landfills and releasing harmful greenhouse gas emissions that contribute to the acceleration of global warming.[2] Indeed, food loss and waste is generated along the entire food supply chain, however in developed countries such as the United States, the end stages – food retail, foodservices and consumers have been identified as key targets to focus reduction efforts.[3] Wasted food at these stages of the food supply change is typically the result of consumer behavior and is referred to as "food waste." Examples of food waste include spoilage, rejected "ugly produce," and leftover food that goes uneaten due to over preparation and plate-waste.[3-5]

In 2015, the Environmental protection agency (EPA) and the United States Department of Agriculture (USDA) announced a national goal to reduce food waste by 50% by 2030.[6] In order to achieve this goal, action is required across all national, state and local government agencies, all businesses, non-profit organizations, academic institutions, and consumers,

To date, most of the literature investigating the relationship between food waste and consumer behavior has been conducted at the household level.[7-11] Presently, there is limited data and information of food waste environments among higher education institutions. These institutions have been identified to generate significant volumes of wasted food, reportedly up to one-billion pounds every year.[7] Although there have been some quantitative[7-10] and qualitative[11,12] efforts to understand food waste issues in the university settings, additional work is needed to better understand the food waste environment, and to identify the strategies that may be effective in reducing food waste in this setting.

1.2 Project Aims and Objectives

The overall objective of this study was to better understand the food waste environment in the university setting. In order to achieve this objective, the study had two primary aims:

Aim 1) To quantify the volume of plate waste generated in a university dining hall facility and estimate the resulting nutritional and environmental implications.

The purpose of the first aim was to answer the following research questions, 1) what is the magnitude of plate waste generated by students in the university dining hall facility; 2) what types of foods are students wasting more frequently in the university dining hall, and 3) what is the potential impact related to nutritional and environmental stability that can be made in this setting with plate waste reduction?

Aim 2) To investigate the psycho-social drivers and food waste related activities influencing food waste behavior among college students.

The purpose of our second aim was to identify the attitudes, beliefs and food related activities that may motivate students to reduce their food waste, and that may also act as a barrier to food waste reduction. Additionally, we aimed to gain insight into the food waste reduction strategies that might be best accepted by students and that may be most effective in reducing the volume of food wasted by students in this setting.

Chapter 2: Literature Review

2.1 Food System and Food Waste Issues

A sustainable food system is defined as, "*a food system that delivers food security and nutrition for all in such a way that is economically, socially, and environmentally favorable to provide food and nutrition security for future generations."*[13] Over the last several decades, researchers have studied our food system from global and local perspectives and various frameworks and strategies have been proposed for transition to a more sustainable food and agricultural system, with a focus on food waste reduction.[3-5,14]

Globally, one-third of all food produced for human consumption is wasted along the food supply-chain.[3,15] The drivers of this wasted food differ from developing to developed countries. In most developing countries, food waste is a product of faulty financial and technological infrastructures; providing limitations in harvesting techniques, storage and cooling systems, and in packaging and marketing systems.[15] In developed countries, most of the food that is wasted is generated at the later stages of the food supply chain and is driven by consumer behaviors and the food environments in retail and hospitality services.[3-5,15]

The significant quantities of food waste have been associated with increasing environmental degradation and economic hardship for populations.[3,16] Growing food that never reaches the mouths of consumers represents a loss of money and of natural resources that were invested in agricultural production such as land, water, energy, and farming fertilizer/pesticides.[3,5,16] For example, it is estimated that food waste consumes 21% of all fresh water, and costs a household of four, $1,800 on average, annually.[3] Additionally, food waste makes up the largest component of the landfill, and releases

harmful greenhouse gas emissions that have been associated with the acceleration of global warming.[4,16]

Food waste also represents significant nutrient loss and social vulnerabilities.[5] Food waste decreases the availability of the food supply, which ultimately increases consumer demand and market food prices, making food less accessible to those affected by poverty.[5] It has been estimated that food waste at the retail and consumer level contribute to a loss of 1,217 kcal to 1,400 kcal per person, per day,[5,17-18] and additional essential vitamins, minerals and dietary fiber.[17] In a world where 815 million people are suffering from hunger every day, throwing away finite resources, money and nutrition is inefficient, unethical and the result of a flawed system.[2]

Food waste reduction strategies are suggested to have an enormous impact on alleviating these harmful consequences. Munesue et al. estimates that a 50% reduction in food waste among consumers and retailers in developed countries, such as the U.S., can alleviate 63 million undernourished individuals, and aid in preserving environmental resources such as land, water and energy.[19] This estimation alone, defines the food waste problem and provides evidence supporting system-wide policy change initiatives for food waste reduction to support a sustainable food system.

2.2 Food Waste at the Consumption Stage of the Food Supply Chain

The largest proportion of food waste in the U.S. occurs at the consumption stage of the food supply chain.[3,4,15]At the consumption stage, edible food is discarded in the household, and in food retail and foodservice establishments, including: grocers,

restaurants, fast food chains, sporting stadiums, schools, universities, hospitals, hotels, prisons, and other organizations that provide a cafeteria or catering activities. [3,4,15]

In 2010, it was estimated that households and food service operations in the U.S., together threw away 90 billion pounds of food, or 21% of the total food supply.[3] Most of this food was edible at one time, and thrown away because it was no longer wanted, or was allowed to go past its best quality or spoil. Multiple factors can be attributed to this food waste, including high consumer expectation of quality,[20] having poor food management skills,[21,22] and several underlying attitudes and beliefs related to food waste that influence individual behavior.[20,23-24]

The hidden cost behind the food that is thrown away at the consumption stage of the food supply chain holds economic, environmental, and social consequences. Targeting food waste reduction initiatives to consumers and food services has the highest potential to put food and money back into circulation, alleviate environmental stress and improve nutrition and food security among populations.[3-5,25]

2.2.1 Food Waste in the Household

Fundamentally, individual households in developed countries, alone, are estimated to contribute the largest proportion of food-waste.[25] Estimated magnitudes at the household level are variable; in Switzerland, it is estimated that 5.33 portions (or handfuls) of food is discarded per household per week,[24] in the UK, the Waste and Resources Action Program (WRAP) has estimated that 7300 kg (7.3 metric tons) of household food is wasted annually,[25] and in the U.S., it is estimated that 0.6 pounds (0.279kg) of food is wasted per person per day.[26] The variability of estimates make

comparability challenging, and provides a disadvantage for better understanding the problem, and for determining the best action to be taken.

2.2.2 Food Waste in Hospitality and Food Services

Literature quantifying the volume[25-26] and drivers of food waste[20-24] at the household level dominates this field of study. Comparatively, the literature defining the food waste problem in the hospitality and food service sector is much less. The food service sector is defined as the business or institutional activities responsible for any food or meal prepared and served outside of the home to consumers.[27] The most recent statistic estimates that U.S restaurants generate 22 to 33 billion pounds of food waste each year.[4] An additional seven to eleven billion pounds is generated from "other" food service institutions including universities, schools, hotels, health-care facilities and other locations with a cafeteria or catering services.[3]

Evidence suggests up to 75% of food that is wasted in the hospitality and food service sector each year is avoidable and could have been eaten.[25] On average this waste arises from spoilage (21%), food preparation (45%) and consumer plate waste (34%).[25]

Various reasons have been attributed to the generation of food waste in the food service sector. The most prevalent has been difficulty for food service employees to forecast the magnitude of meal demands and provide an accurate number of servings, often leading to over-preparation of the food and serving large portions. Consumer expectations of the quality and preparation of foods and desiring only to have the best grade and quality have also been suggested to influence food waste among food services.[27,29] Additionally, the type of food service style has been associated with food

waste. Food service styles that operate on an all-you-can eat buffet style have been associated with more food waste than the al-la-carte or cook-to-order services.[27,28]

2.2.3 Food Waste in Higher Education Institutions

Higher Education institutions have been identified in the literature as the largest producers of food waste in the food service sector,[30] and it is estimated that these institutions produce over 1 billion pounds of food waste annually.[7]

The few studies available investigating food waste in the university setting are mostly gray-area literature, available as a student capstone or honors project, and primarily focus on food waste quantification estimates in university dining hall facilities. Among these studies, observations of food waste took place in either one dining hall facility or multiple dining hall facilities and the duration of observations varied from a period of three hours to one-day to six-weeks. Some studies investigated solely student plate waste,[31-33] while others investigated plate waste in combination with kitchen waste (waste produced before or during the cooking process) and serving waste (edible food that is served but not eaten).[8,33]

Some studies have further categorized the wasted food into sub-categories; which generally included starchy carbohydrates, animal products, including meat, dairy and eggs, and organic material such as fruits and vegetables.[32,33] Starchy carbohydrates were consistently found to produce the largest proportion of wasted food in the university dining hall. [8,32-33] However, one study did observe organic material, which consisted of cooked and raw fruits and vegetables, to have the highest proportion of food waste, with estimates as high as 53% of total food waste observed.[8]

Fundamentally, these studies have recognized the significant quantities and potential for food waste reduction strategies in this setting. Plate waste has been found to make up the largest component of the food waste investigated, respectively about 41% to 63% of the total food waste observed,[33,34] and quantities were observed to range between 0.1 pounds (1.6 ounces) to 0.98 pounds (15.7 ounces) per meal each day.[7,8,32,33]

Food waste estimates were generally variable due to many factors including the differing methods used for quantification, the food culture, including the type of food service style and the meal booking system, the sociodemographic profile of students, and the proximity of university dining facilities to student housing.[36] A standardized protocol for quantifying food waste in this setting is needed.

2.3 Key Factors Affecting Food Waste at the Consumption Stage

Consumer food waste is a complex phenomenon that is a function of multiple personal, cultural, political, geographical, and economic forces that influence behavior.[36] As populations are rapidly growing, urbanizing and becoming wealthier,[37] a combination of increased consumer food choices and a decrease in the proportion of disposable income spent on food has been observed that tend to increase wasteful behavior.[5]

In developed countries, as household incomes increase, a shift in consumer diet has been observed, where there is more consumption of vulnerable, shorter shelf-life items such as fresh fruits and vegetables, dairy, meat and fish that tend to increase wasteful behaviors.[16] Consumers have also adopted a high expectation of food quality standards,[5] which have been suggested to increase household food waste due to desiring only the freshest foods and heightened food safety concerns.[16]

Studies from the UK show that household composition may be related to the amount of food that households throw away.[20] Larger households, households with more children,[38] and higher income households have been associated with more food waste.[21] Households that spent more on groceries, went out to eat more and took fewer grocery trips during the week have also been associated with more food waste.[38] Additionally, households with younger individuals responsible for preparing the food have been associated with more food waste,[20] and women have been associated with wasting more than men.[33]

Food management activities such as food planning, food shopping, preparing or cooking food and having the knowledge of how to properly store food, and interpret food dates are also associated with food waste.[20-22,24] Activities such as buying or cooking too much food, not planning meals in advance, failing to create a grocery shopping list, and impulse purchasing are associated with more food waste.[16]

Several consumer attitudes and beliefs relating to food waste behaviors have also been investigated.[20-24] Motivating factors that may reduce individual food waste include feeling bad about throwing food away;[23] having financial concerns about wasting money,[24] perceiving fewer health risks in leftovers and foods that had passed their use-by date,[23,24] and having a greater sense of perceived control in reducing food waste.[21,22,24] Barriers that impede food waste minimization include factors related to food management skills and perceived inconvenience.[23] Having the desire to shop, cook and prepare food with convenience, and stocking up on food items by buying in bulk to avoid an extra trip to the grocery store has been associated with more food waste.[21-22,24] Additionally, consumers who saw taking time off from work as an inconvenience have reported to

throwing away leftovers due to not wanted to risk the chance of becoming ill from eating them.[23]

Few studies also exist that have begun to investigate factors that may influence food waste behaviors among students in higher education institutions.[7,11-12,39] It has been suggested that plate waste in dining halls is driven by students not liking the food that is served, being unsure of what the food will taste like and thus try many different meals, and feeling too busy to finish their meals.[39] Other studies suggest that students are unaware of the magnitude of the food waste issue, and if they had the knowledge, they would waste less food.[7-8] Yet others suggest that students knowingly take too much food, because they feel they have no control over the best way to minimize their waste.[39] With dining hall services and other food outlets around campuses holding most of the food management responsibility, students have reported often feeling a lack of accountability to reduce their food waste, and uncertainty that their individual actions could make a difference.[7] Still other literature suggests factors similar to those found among household studies, including; challenges when managing food planning, purchasing and preparation and a lack of knowledge of proper food management.[11]

2.4 Impact of Food Waste

2.4.1 Environmental Impact

Agriculture and food production have substantial impact on resource use and environmental sustainability.[40] Throughout the food supply chain, food production uses 16% of the total US energy budget.[3] Growing food that is never eaten contributes to unnecessary usage of agricultural resources. Nearly 50% of available US cropland, 67%

of the nation's freshwater usage, and 18% of all farming fertilizer is consumed in our food waste.[3] Additionally, food waste continues to represent the largest component in landfills in the U.S. at 21%. Decomposing food in a landfill releases methane gas which directly contributes to global warming. Methane gas released from food waste contributes to 34% of all human-related methane emissions in the U.S.,[41] and further contributes to 2.6% of global greenhouse gas emissions annually.[3] It is estimated that food waste at the retail and consumption levels contribute to 1.4 kg CO2 equivalents/capita/day.[40] The evidence presented represents harmful consequences to our environment, including the acceleration of global warming and a waste of the resources that went into growing, producing, processing and transporting food that is wasted.[15] The impact of food waste on the environment is particularly concerning because population growth and evolving consumption patterns will lead to higher global demand for food and amplified environmental pressure.[37] In fact, it is estimated that if waste levels remain unchanged, global food production will have to increase by 70% to feed the growing population,[5] further augmenting the problem of food waste. The critical impact of food waste on the environment has been recognized world-wide, and currently, sustainable food waste reduction is one of the top three priorities on national agendas (SDGs).[42]

2.4.2 Financial Consequences and Nutrient Loss

Wasted food is not only detrimental to the environment but also costs consumers and businesses substantial amounts of money and nutrition. In the U.S., Americans throw away an average of more than 1,250 calories per person per day,[5,17,18] the equivalent of more than 400 pounds of food per person annually.[5] This figure is equivalent to a loss of up to $218 billion dollars each year, and 1.3% of the U.S. gross domestic product

(GDP).[4] The economic value behind this wasted food is estimated to be 9.2% of household spending,[43] the equivalent of costing a household of four an average of $1,800 annually.[4] Additionally, food waste contributes to an increase in demand and food prices, making healthy food less accessible to those affected by food insecurity.[5] The most recent studies to date, estimate that the highest proportion of food waste is composed of our most perishable types of foods, that are also the most nutrient dense. These types of food include fresh fruits and vegetables, dairy products, meat and fish.[3,5] Further, the nutritional value of wasted food is estimated to be 33 g protein, 5.9g dietary fiber, 1.7ug vitamin D, 286 mg calcium and 880 mg potassium per person, per day.[17] This wasted food not only represents a loss of calories and key nutrients that are essential for adequate nutrition but is also representative of increased food prices and consumer expenses that ultimately reduces accessibility to quality, nutritious food items, threatening the food security of populations, globally.[44]

2.4.3 Food Waste and Food Insecurity

Food insecurity is defined as the limited or uncertain availability of nutritionally adequate and safe foods.[45] In the U.S., 11.1% of all US households (14.5 million households) experienced food insecurity sometime during the year in 2018.[46] In recent years, more evidence has emerged that has defined the negative influence of food insecurity on the physical and mental health outcomes in children and adults.[46] Household food insecurity in the U.S. affects the food selection and dietary intake of individuals, resulting in a lower diet quality with inadequate intakes of fruits, vegetables and dairy,[47] and inadequate intakes of Vitamin A, Vitamin B-6, folate, calcium, phosphorus, magnesium and zinc.[46,47] Dietary fiber, potassium and Vitamin D are also

nutrients of public concern according to the 2015-2020 Dietary Guideline for Americans.[48]

Food insecure adults are also at increased risk of developing chronic disease and mental health issues such as depression and sleep apnea. Children that are food insecure are at increased risk of anemia, cognitive issues and having aggression or anxiety, and of developing chronic disease related to overweight and obesity later in life.[49] Recent studies are now beginning to confirm similar trends of food insecurity in higher education institutions.[49-57] This is troubling, especially when evidence indicates that by avoiding food waste, globally, there is enough food produced to meet the nutritional needs of our entire population.[2]

2.4.4 Food Insecurity and Nutritional Inadequacies Among College Students

Evidence on the prevalence of food insecurity at U.S.-based universities began to emerge in 2008, by accident, when a university group was conducting an evaluation of a financial aid program.[57] Since then, more research has emerged at several large public universities around the country. Studies suggest that the prevalence of food insecurity at higher education institutions ranges from 14% to 59%,[49-57] double that of the national statistic. An average prevalence among students suggests that every one-in-five students are food insecure.[57] The evidence confirms that the problem of inadequate nutrition exists in the university setting and that college students are vulnerable to becoming food insecure.[49-57]

Food insecurity among this population has been consistently associated with self-reported poor health, poor financial management and adverse academic outcomes.[55] Further data suggests that food insecure students do not physically have the adequate

finances to support essential expenses, including housing, nutrition, healthcare, transportation, and school associated costs.[51] In fact, food insecure students were found to engage in food related behavioral coping strategies such as; purchasing cheap and processed foods, stretching food, eating less healthy meals to consume more food, and planning menus before buying food.[58] The evidence indicates that although enough food or healthy food may be available for purchasing on campus, these students do not have the financial capacity to purchase enough food and/or healthy foods to meet their nutritional needs. Action is needed to increase the affordability of nutritious foods on campus.[58]

Despite the emerging evidence, little has been done to alleviate food insecurity in this population. The most suggested strategies for higher education institutions have been; to provide education and training of financial management skills, to promote food donations among peers, faculty and staff, and to provide students with emergency food items through a campus food pantry.[56] In response, some universities have invested in campus food pantries, however the impact of this resource is not well identified. A report published by the University of Maryland, campus newspaper, revealed that many students reported reluctance to ask for help and a discomfort in going to the pantry in fear of discrimination due to lack of enough foods.[59] To our knowledge, only one study has examined the relationship between food insecurity and food pantry use; finding that only 38% of students utilize campus food pantries and report barriers such as social stigmas, uncertainty on usage policies, and inconvenient hours.[60]

Recent studies have begun to recognize a modern and innovative strategy for alleviating food insecurity; and the concept is grounded in the notion that “waste” can be

a "resource."[61] This concept implies the potential of a synergistic solution that not only alleviates food insecurity among populations but also reduces systematic food waste, by re-distributing surplus prepared foods to groups affected by food poverty. The reduction of food waste through recovery and re-distribution has the potential to deliver substantial environmental, economic, and social benefits. It is a food waste reduction strategy that has been promoted by the U.S. Environmental Protection Agency as a solution for Americans to achieve sustainability among their communities.[14] This type of initiative has not been well explored in the University setting to aid food insecure students.

2.5 Methodologies to Assess Food Waste

2.5.1 Methods of Quantifying Food Waste

National estimates of food waste quantities are the most abundant in the literature.[3] In the United States, these estimates are generated by five main organizations that estimate food waste quantities by extrapolating various data related to the national food supply and national nutrition data (see Gunders & Bloom Appendix A- page 45).[3] These organizations include; the USDA, EPA, NIH, ReFED and FAO. Estimates are limited by the assumptions associated with each data set, which vary based on the organization.[3] Included below are the details of the USDA, Economic Research Service (ERS) Loss-Adjusted Food Availability Documentation (LAFA) Data Series. The data series tracks 213 food commodities in the retail and consumption stages by use of nationally representative surveys of retail inventories/shipments, household purchases, and stated assumptions to approximate the intake of Americans.[62] The availability of food

is adjusted for food spoilage, plate waste and other food wastage which provides a food waste estimate.[63]

Methods for quantifying consumer food waste from residential settings, such as households, consist mostly of self-reported estimates. Methods such as household weighing and kitchen diaries require self-assessment at the point of disposal, where the consumer either weighs their waste contents or provides an estimate based on observation.[64] Methods that require consumers to recall the type and amount of food that they typically throw away include qualitative assessment using focus groups,[23] and survey questionnaires.[21,22,24,43] These methods are utilized when researchers attempt to link behavior to self-reported amounts of food waste. The disadvantage of consumer self-measurement is the subjective awareness of the behavior that may lead to measurement bias. Consumers may consciously or unconsciously misreport how much they waste.

In the university setting direct weighing of food waste estimates is identified as the gold standard due to its high reported accuracy.[65] The few literature investigating estimates of food waste in the university setting have utilized this method of quantification.[7,8,66]

2.5.2 Assessing Environmental and Nutritional Implications of Food Waste

To provide context to the value of food waste reduction strategies, it is also essential to investigate the implications of food waste. Most research efforts have focused on the economic value,[5,15,19] and few studies have examined the environmental significance[40,44,66] or nutritional value of wasted food.[5,17,18]

The few studies that have investigated the implications of food waste have been conducted as national estimates utilizing public available national and local data reserves

to estimate food availability and food waste along the food supply chain and then applying various mathematical modeling to calculate the financial loss,[5,15,19] land-, water- and energy-loss, greenhouse emissions,[5,40,44,66] total calories lost, and nutrient content of the food waste.[5,17-18] For example, one study examined the nutrient composition of food waste in the United States by use of two USDA data sources; the 2010 LAFA (Loss-Adjusted Food Availability) Data Series, for estimating food waste at the retail and consumer level, and the USDA National Nutrient Database for Standard Reference, Release 28 (SR-28), for estimating the nutritional composition.[17] The National Nutrient Database for Standard Reference is the major source of food composition data in the U.S, and The SR-28 is the most recent release for 2017-2018 (SR-28). [67]

A few studies have also aimed to estimate the greenhouse gas emissions resulting from the production of food that is wasted at the retail and consumption stage of the food supply chain.[40,68] Venkat, 2012 conducted a meta-analysis of studies utilizing a life-cycle assessment (LCA) approach to estimate the greenhouse gas emissions related to the production of a variety of food items, and extrapolated these findings to the national food waste estimates provided by the LAFA Data Series.[69] Heller, & Keoleian, 2015 adapted the same approach as Venkat, 2012 but with the most recently published 2010 LAFA Data Series. [40]

2.6 Previous Approaches to Reduce Food Waste

Due to the complexity of the food waste problem, the USDA and the Environmental Protection agency created a consumer-friendly Food Recover Hierarchy to help guide priorities for managing food waste.[69] Strategies at the top of the hierarchy are prioritized

because they include efforts that are suggested to have a greater environmental benefit than strategies lower on the Hierarchy. The higher the strategies on the Hierarchy, the more effective it is estimated to be for addressing food waste reduction and include, prevention (source reduction) and donation or redistribution to organizations that serve food-insecure populations.[14]

2.6.1 Preventative Actions to Reduce Food Waste

Preventative actions involve reducing the amount of food waste generated.[14] Current approaches for preventative actions include raising consumer awareness to the issue of food waste and discouraging the behaviors that lead to waste by actively seeking to change behavior and by rethinking current practices and systems in place.[3,5,14]

In 2011, a global discussion regarding innovative solutions to enable food systems to reduce food loss and waste in both the developing and industrialized world was given a platform called the SAVE FOOD Initiative.[70] The SAVE FOOD initiative aims to drive innovations, promote discussions and spark debates to generate solutions at every stage of the food supply chain.[70] Thus far, it has stimulated increased awareness of the significance of the problem and has sparked a conversation toward innovative solutions to food waste reduction. The most notable efforts have been the Think – Eat – Save anti-food waste and food lost campaign. This campaign encourages individual reduction by allowing consumers to track their carbon footprint, and interact with food-waste reduction tools such as the "Guest-imator" that allows consumers to calculate how much food they will need for a dinner party, and also helps to plan the meal and create the grocery shopping list.

Further, in the UK, the Waste and Resources Action Program (WRAP) is promoting the Love Food, Hate Waste campaign.[71] This campaign targets consumers and provides the facts about food waste and strategies for food waste reduction in the household related to food planning, shopping, preparing, storing food and reusing leftovers. Most notable, the campaign features tons of recipes on an easily accessible website and provides a monthly newsletter that features food management tips for reducing food waste.

Some examples of local food waste prevention efforts that focus on changing the current practices and procedures among food retailers and grocers, are listed below.[3] In some food retail organizations, "ugly" produce is being sold at a discounted price to consumers.[72] Grocers in the UK are testing ethylene-absorbing strips for increasing the shelf life of products such as tomatoes, avocados, and strawberries.[73] The Lean Path software has been used in many food services for tracking food items that are wasted by consumers.[74] Some initiatives are also directly aimed at the consumer. Some retailers are including the storage instructions with the purchase of fresh produce to inform consumers of the best practices, [75] and some are including new food labels that urge the consumers to freeze food past the use-by date. Some food services are serving smaller portion sizes, decreasing the number of options to choose from on the menu,[76] and even charging consumers a fee for unfinished foods. Specifically, in university dining halls, few studies have piloted educational campaigns by use of posters and creative messages.[7,11,12] Messages highlighting the environmental, economic and social consequences of the food waste problem such as, "uneaten food represents a loss of $165 billion each year," were intended to improve waste behaviors among students. Results of these studies are

conflicting. One study observed a 15% reduction in quantities of plate waste among students,[7] while another observed no change in food waste behaviors.[12] Findings indicate that educational campaigns targeting students may be more effective in reducing food waste when combined with structural changes in the food environment. For example, some cafeterias have also transitioned to tray-less dining, in which students are discouraged to overload large cafeteria trays. Tray-less dining has been estimated to reduce food waste by up to 30%.[77]

2.6.2 Recovery Actions to Reduce Food Waste

Secondary to prevention strategies, food recovery and re-distribution is estimated to be the next most effective solution. Food waste recovery diverts waste from landfills and is often distributed to groups affected by poverty.[3,14] Food recovery has been around for over 30 years, primarily as anti-hunger efforts that divert surplus food to organizations such as food banks. To date, in the U.S., only about 3-10% of food that is available for recovery is recovered, leaving 52.4 million tons that are still discarded to landfills, and another 10.1 million tons that are left on farming fields.[78]

Recently, start-up non-profit organizations have also been participating in recovery actions to reduce food waste. Community programs such as "Hungry Harvest," based in Washington D.C,[79] and "Imperfect Produce," in San Francisco bay area,[80] rescue cosmetically challenged or "ugly" fruits and vegetables, that would otherwise go to waste, to individuals and families in the community. Additionally, in the university setting, a program called, The Food Recovery Network (FRN) was launched in 2011 at the University of Maryland.[81] The FRN works to recover leftover food from college dining hall facilities and deliver it to nearby organizations that serve people in need.[81]

The network has expanded to over 200 campuses across the country. Finally, a new movement, called "Too-Good-To-Go," uses a mobile application to connect consumers to leftover ready-prepared meals from restaurants and cafes in the community at a very low price. The application is only available for use in the UK, but in less than two years, the program has rescued over 2.5 million meals, and expanded its services to some university campuses in the UK.[82] The feasibility of food recovery and donation to students in higher education institutions is presently undetermined. Risks of food recovery such as food safety risks, food distribution and storage logistics, and finding the volunteers to recover the food can create challenges for university dining services. However, the Emerson Food Donation Act, signed into law by President Clinton in 1996, and the Food Donation Act, 2008 have encouraged food donation by protecting donors from food-safety liability.[3] It would be interesting to investigate whether food donation to students on campus could be a safe, and feasible option.

2.7 Recommendations for Food Waste Reduction in Higher Education Institutions

It has been suggested to approach food waste reduction in the university dining hall by promoting change in consumer behavior, and with structural change of the food environment.[3,12,84] Although it is unclear the best strategies for food waste reduction in this setting, few studies have provided some insight. Some of the best insights have come from a qualitative study among 58 young adults aged 18-24 years in which most were attending university.[11] Nine focus groups were conducted suggesting that young adults generally had a low knowledge and awareness of the food waste issue and this was connected to a lack of perceived consequences of food waste. Taste preference was

reported as a key factor influencing food waste behaviors. Having busy schedules and a lack of skills for engaging in food management behaviors were also reported to be associated with food waste. Some reported feeling guilty about wasting food, while others reported a complete disconnect with the hidden cost of wasting food.[11]

Additionally, some operational changes have proven to be effective in few studies. Removing trays from dining halls have been suggested to prevent over-selection of food,[85] and pre-portioning food items may also help students control the amount of food the select.[76] It has also been suggested to provide samples of food items so students may familiarize themselves with the taste of unknown or unfamiliar foods.[12]

Fundamentally, it has been recommended for higher education institutions to conduct routine food waste audits in order to understand the scope of the food waste problem in this setting and to identify opportunities within the system to intervene.[3] Despite this recommendation, standardized protocols for conducting food waste audits in this setting have not been identified. Further, there is a need to investigate food waste behaviors among students using a comprehensive model to identify the most critical factors that should be targeted in food waste reduction interventions in this setting.

Chapter 3: Methods

3.1 Conceptual Framework

Understanding the issue of food waste is complex, requiring knowledge of many factors that involve the investigation of the system as well as the psycho-social drivers and behaviors that influence behavior. Proposed in this project is a preliminary, exploratory research adapting the social cognitive theory and the theory of planned behavior to investigate the environmental, behavioral and personal factors influencing food waste behaviors among students in the university setting. The Theory of Planned Behavior (TPB) will guide investigation of the psycho-social drivers and food-related activities influencing food waste behaviors. An investigation of the external inputs that may influence food waste behaviors among students will also be evaluated in a university dining hall facility. The conceptual framework is shown below in Figure 1.

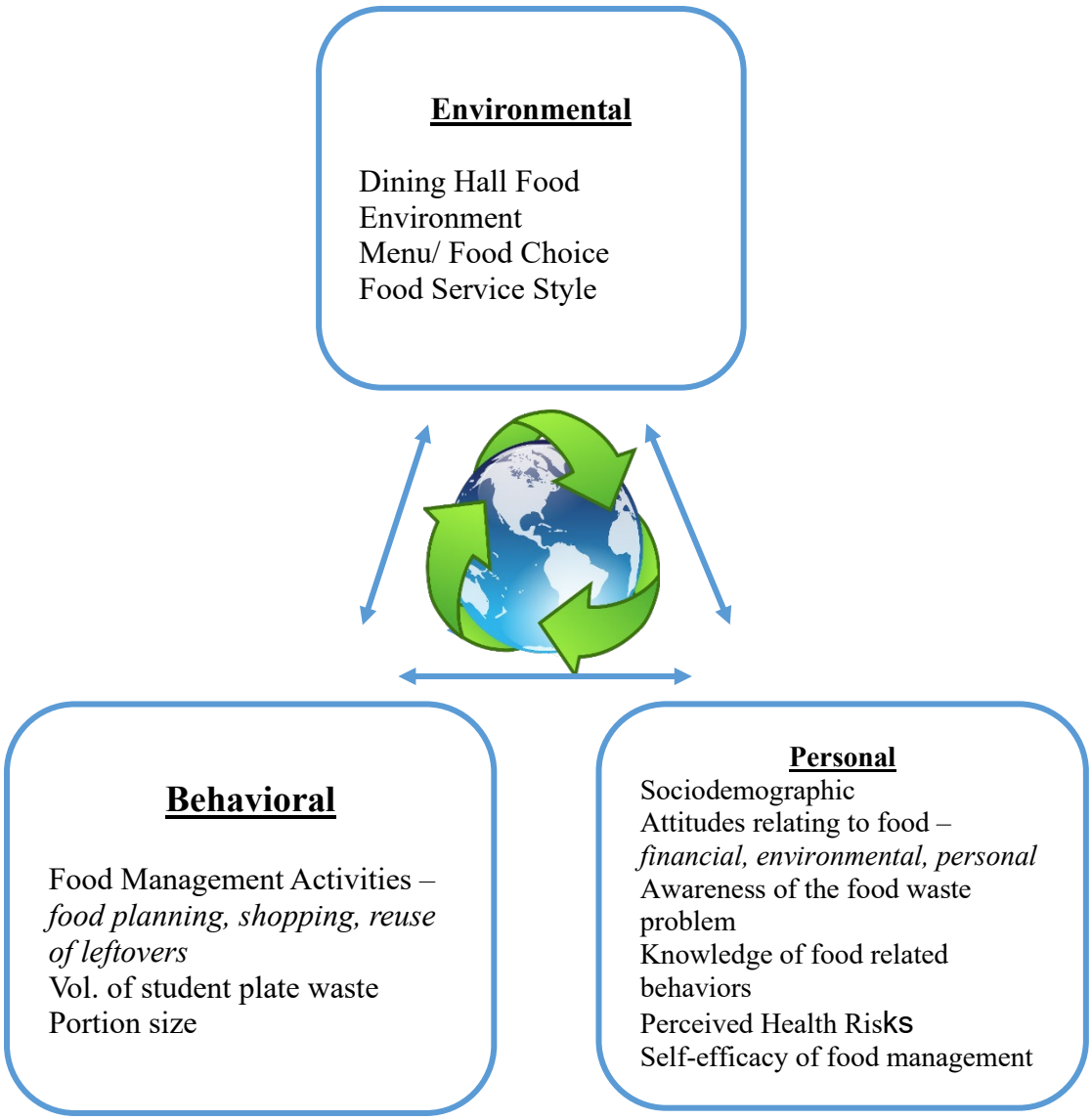


Figure 1. Conceptual framework of the evaluation of the food waste environment in the university setting

3.2 Study Overview

This project took place at a large, public university. Two phases of data collection occurred, including a food waste audit and an online behavioral survey. The methods

included in each of these activities are summarized below and described in more detail in Chapter 4 (paper 1) and Chapter 5 (paper 2).

Approval by the University of Maryland, College Park Institutional Review Board and research approval from the University dining services were obtained prior to recruitment for this formative study.

1) *Food waste audit:* Student plate waste was collected and weighed in a university dining hall facility. The volume of student plate waste was determined, and the hidden nutritional and environmental value of the plate waste was calculated.

2) *Student survey:* Guided by the Theory of Planned Behavior (TPB), a survey questionnaire was created and distributed online to university students. The questionnaire was intended to measure the psycho-social drivers and food-related activities influencing food waste-related behaviors among students.

3.3 Study Setting

Student profile: Research was conducted at the University of Maryland, College Park, a large, public and diverse university of approximately 40,521 students of which 74% are undergraduate students, and 26% are graduate students. The distribution of socio-demographics among students are as follows; gender; females (47%) and males (53%), race & ethnicity; White (46.8%), African Americans (11.4%), Asian (14%), Minority (12.1%), Unknown U.S. (3.1%), and foreign (12.8%). The student body is divided by class standing, including, freshman (8.5%), sophomore (16.8%), junior (19.8%), senior (27.3%) and graduate (25.4%) students.

On-campus dining options: At the University of Maryland, College Park, about 40% of the student body live on campus, in campus housing facilities, and have the option of dining at the three university dining hall facilities - North Campus Dining Hall, South Campus Dining Hall and 251 North Campus Dining Hall. These dining hall facilities operate on a pre-planned, three-week rotating menu schedule. On any given day, each dining hall will provide a different menu that corresponds to one week of the respective rotating schedule. However, as the menu rotates throughout the entire semester, each dining hall will essentially serve the same meals. Due to the similarities between all three dining hall facilities, this formative research will focus on one of the three dining hall facilities.

Dining hall facilities operate an all-you-can eat (buffet-style dining), and a variety of food items from six meal stations are served daily. These include: an Italian pizza and pasta station, a grille station for grilled chicken and meats, as well as fried foods like french-fries and onion rings, a sandwich station offering both meat and meatless sandwich options, a cold salad station, a vegan station where students could choose plant-based proteins to include in a salad, sandwich or sushi, and a traditional hot meal station serving meat or fish, and a variety of sides and bread. Two hot soup options and an assortment of dessert items are available each day including an ice-cream bar, and an assortment of cookies and cakes. Food items are self-serve except for a few items such as large cuts of meat that require food service staff to carve individual servings upon request. All food items are labeled with a 2 x 3.5-inch food label including the name of the food or dish and potential allergen information.

Not everyone living on campus is required to use campus dining services. However, students living in traditional dorm facilities are required to have a dining plan that would allow them to eat at the dining hall seven-days a week. Dining halls are open all-day from 7 AM to 11 PM, seven days a week. Students living on campus and students living off campus also have access to the two full-service restaurants, 19 cafes located in classroom buildings, the campus food court that includes Chick fil-A, Sbarro, Subway, Taco Bell and Auntie Anne's, six campus convenience shops, and a mobile dining food truck. Campus dining services manages the food procurement, preparation and distribution at all these locations, providing an estimated 27,000 meals per day to the campus community. In recent years, dining services has transitioned to adopt more sustainable practices in their everyday food services, in support of the UMD's pledge of sustainability in 2007 when it joined the American College and University Presidents Climate Commitment.

Initiatives & operation of UMD dining service: In 2012, UMD dining service developed their own sustainability goals to provide more nutritious and environmentally, socially and economically sustainable food to campus diners. Many commendable strides have been made by dining services and they have already met their major goal of purchasing 20% of all food purchases from local and sustainable vendors. Other initiatives that have been implemented include, providing a campus farmers market, creating a student-run campus farm in the community, and building a campus food pantry. Initiatives that directly altered the operation procedures of dining hall services towards a more sustainable food service also were implemented. These include increasing the purchasing of locally grown, whole foods from community farmers, managing

surplus food waste through recovery by the food recovery network, elimination of trays in the dining halls, and prohibiting the use of "to-go" containers. Additionally, recycling, and composting systems were set up in all major dining halls.

3.4 Data Analysis

The data collection tools and activities included in this research evaluated key personal, behavioral and environmental factors influencing plate waste at the individual level, specifically among students enrolled in higher education institutions, and further explored the potential implications of food waste reduction strategies. Evaluation and analysis of these measures are summarized below and described in more detail in Chapter 4 (paper 1, page 29), and Chapter 5 (paper 2, page 49).

3.4.1 Analysis of Student Plate Waste

The volume of student plate waste was collected into six main food groups, determined based on the nutritional value and environmental impact. Food groups were coded as: starch and added sugars, fruits and vegetables, dairy, animal proteins and fish, plant-based proteins, and whole grains. Descriptions of each food group are listed in Table 1.

Table 1. Food Groups to Collect Student Plate Waste

(1) Refined Starch & Added Sugars	• Refined white grains including white bread, rice, pasta and baked goods; • Starchy vegetables including potatoes, corn and peas; • Any item made with added sugars including condiments, salad dressing, sugar-baked apples and fruit pies; • Starch thickened gravies and sauces.
(2) Fruits & Vegetables	• All fresh, frozen, canned or dried fruits and vegetables, encompassing both raw and cooked options; • Marinara and tomato sauces, fresh salsa, avocado, and vegetable broth or soup; • Orange juice.

(3) Dairy	• All milk-based products, including milk and coffee creamer, yogurt, ice-cream, butter; • Cheese(s), including soft and hard cheese, cream-cheese, sour-cream and ricotta cheese; • Cream-based sauces and soups.
(4) Animal Proteins & Fish	• Meat, poultry and fish, including shell-fish; • Eggs and egg-based products such as mayonnaise, meringues and custards.
(5) Plant-Based Protein	• Legumes including beans, lentils, soybeans and chick-peas; • Nuts and nut butter; • Soy derived meat alternatives such as tofu, tempeh, and seiten; • Vegan cheese made from soy and/or cashews; • Smoothie or drink mixed with plant-protein (i.e.. pea-protein).
(6) Whole Grains	• Whole-grain bread and wraps, cereal, pasta and brown rice; • Barley, quinoa, faro, couscous and oats; • Items made from whole wheat flour, including whole wheat flour, semolina flour, durum flour, graham flour, buckwheat, and rye flour.

Further investigation of the volume of student plate was done to explore the nutritional and environmental implications of student plate waste in this setting. The USDA National Nutrient Database for Standard Reference, Release-28 (SR-28)[68] was used to contextualize the nutritional value of plate waste, including 13 nutrient components. Additionally, we estimated the greenhouse gas emissions associated with the production of food that was discarded as plate waste. Estimates were calculated using a method adapted from previous literature,[41,69] in which the greenhouse gas emissions of several foods were estimated using a life-cycle analysis approach.

3.4.2 Analysis of the Behavioral Survey

The data were analyzed using the IBM SPSS, version 26. Descriptive statistics were used to describe baseline characteristics of the sample. Correlations between the psycho-social drivers, food related activities and self-reported amounts of food waste were assessed, and hierarchical linear regression was used to identify the key factors that may influence food waste behaviors among this population.

Chapter 4 (Paper 1): Consumer Food Waste and Its Implications For Sustainable Management in the University Setting

4.1 Introduction

In the United States, an estimated 40% of the available food supply is wasted, with consumers identified as the largest contributors.[3,5] This statistic is estimated to be the equivalent of more than 400 pounds of food wasted per person per year and represents a loss of $218 billion and over 1,250 kcal/person/day.[3] Previous studies quantifying the volume and drivers of food waste have been primarily conducted at the household level.[86,20-21,24] Comparatively, much less literature examining the food waste problem in the retail and food service sector such as restaurants, nursing homes, hotels, schools and higher education institutions is available.

Consumer plate waste - food that is served on individuals' plates but not eaten- is among the largest source of avoidable food waste in the school setting.[65,87] Yet, investigation of student plate waste has focused on primary or secondary schools participating in the national school lunch program,[88,89] with only few studies that have investigated food waste in higher education institutions.[7-11] Higher education institutions are identified to produce significant quantities of food waste, reportedly over 1 billion pounds every year.[7] These settings are uniquely challenged, as university campus dining prepares meals for one of the most wasteful groups of consumers, young adults.[20-21,24] For many young adults in this setting, college represents the first time they have been expected to make their own food related decisions including where, when, and how much to eat.[90]

Among the few available studies, campus dining has been recognized as a major contributor of food waste, and most studies have focused on quantifying waste volumes in

university dining hall facilities.[65,7-9] Estimates of student plate waste range from 18 to 444 grams per student meal (0.6 to 15.6 ounces).[7-10] Food service styles that operate an all-you-can eat, buffet style have been associated with higher quantities of waste than a la carte or cook to order services.[12,39] Additionally, food services that enable students to self-select their desired portion size, as opposed to staff providing portions, have been associated with higher quantities of plate waste.[7,8] Food service models where students "pre-order" meals appear to result in the highest rates of plate waste due to a large number of students never retrieving their pre-ordered meals,[8] whereas students allowed to take leftovers in a to-go box have been observed to produce less waste.[10]

Previous studies recommend that university dining hall facilities conduct routine food waste audits in order to understand food waste production patterns among students, and identify opportunities within the organization for food waste reduction.[3,5,7,8,11] Despite these recommendations, best practices for food waste audits in university dining hall facilities have not been standardized and thoroughly discussed. For example, observation procedures have varied from one meal to multiple meals, occurring over a period of two to six weeks.[7-10] Some studies focused on one dining hall facility,[3] while others investigated multiple on campus.[8,9] Some investigated solely student plate waste,[7,8] while others investigated plate waste in combination with kitchen waste (waste produced before or during the cooking process) and serving waste (edible food that is served but not eaten).[9,10]

Further, little is known of the nutritional, environmental and financial value of student plate waste in this setting. It has been recommended for researchers to contextualize the value of their quantified food waste, as these estimates may better inform food service managers and other policy makers of the impact food waste reduction initiatives can have.[5]

Additionally, behavioral interventions are recommended to highlight the implications of plate waste and improve students' understanding of the impact of their personal food waste behaviors.[7] Presently, there is a lack of knowledge of the implications of student plate waste in this setting.

In this study, we aimed to systematically examine student plate waste quantities in a university dining hall facility and compare food served versus student plate waste using food production records. Plate waste was measured in terms of major food groups to understand the relative contributions of each. We then contextualized the volume of plate waste by estimating the nutritional and environmental value of student plate waste in this setting.

4.2 Methods

4.2.1 Study Setting

During the spring 2018 academic semester, student plate waste was collected from one of three campus dining hall facilities operating at a large university of approximately 30,762 undergraduate students. Campus dining hall facilities provide an all-you-can eat buffet style food service and provide meals to at least 40% of the undergraduate student body - students who live on campus and purchase a meal plan during the academic semester – serving an estimated 27,000 meals per day.

In recent years, a new dining service system called the Anytime Dining Food Service Plan has been adopted. Anytime Dining was adapted to accommodate students who felt their dining plans did not last them throughout the academic semester and changed the food service style from al la carte to an all-you-can-eat, buffet style service.

It allowed students to enter any one of the three dining halls at any time during the day, as many times as they would like and eat as much as they would like. However, students were not allowed to take any food out of the dining hall at any time.

The three dining hall facilities use a pre-planned, three-week rotational menu. On any given day, each dining hall provides a different menu corresponding to one week of the respective rotating schedule. However, as the menu rotates throughout the entire semester, each dining hall will essentially serve the same meals. Due to similarities between all three dining hall facilities, the present study focused on one of the three dining hall facilities. One dining hall was selected based on the university dining service teams' suggestion. It is the smallest of the three and receives the least amount of traffic during the day.

Review by the IRB was not required for this study because human subjects were not involved, as per US Department of Health and Human Services guidelines (http://www.hhs.gov/ohrp/policy/checklists/decisioncharts.html#c1).

4.2.2 Plate Waste Collection and Weighing Procedures

Plate waste was collected at six intermittent cross-sectional days, including two intermittent days in February, March, and April; and two snapshots of the food provided from each of the three rotating menus and two snapshots of the food provided from each of the three rotating menus. This was necessary to control for any variation in menu selection or seasonal food items and recipes used throughout the semester. All leftover food scraps were physically scraped into six, five-gallon buckets; each bucket representing one of the major food groups, respectively, starch and added sugars, fruits and vegetables, dairy, animal proteins and fish, plant-based proteins and whole grains.

Plate waste was collected in the dining room, where data collection procedures were visible to students. All food scraps and used dishes were collected from the time the dining hall opened at 11 am to the time it closed at the end of the night at 8:30 pm. Figure 2 displays the food waste audit set-up. All trash cans and recycling bins were also removed from the dining hall to prevent students from discarding plate waste and ensure all leftover food scraps were accounted for.

Direct weighing was used to collect detailed and accurate information of plate waste among students.[35] Non-edible waste was removed, and food scrapes were sorted by food groups. Cumulative weights of each bucket were recorded every hour beginning at 12 noon and ending at 8:00 pm. One last additional weight was measured at 8:30 pm. Weights were recorded in ounces using a calibrated food scale accurate to 0.01 oz and converted to grams for comparability to previous literature.

A total of six research assistants were recruited from the university's undergraduate Dietetics Program to assist with data collection procedures. Each participated in a 1.5-hour menu training prior to each of the six days of data collection. Menu training consisted of a collaborative workshop to determine how different food items being served would be collected and sorted into appropriate food groups. Participants considered the nutritional content of foods, ingredients, and feasibility of separating combination items, such as casseroles.

Figure 2**.** Food Waste Audit Set-Up. (Photo #1: Top Left) Student Plate Waste was collected into 5-gallon buckets, and into 7 food subcategories. (Photo #2: Top Right) Labeled dish-bins were placed on each end of the buckets, to collect overflow of used dishes, and food scraps. (Photo #3: Bottom picture). Research Assistants blocked off the single conveyer belt to the kitchen, instead collecting all leftover food scraps.

4.2.3 Coding of Food Groups to Collect Student Plate Waste

Food groups measured in this study differ somewhat from those in the Dietary Guidelines for Americans (DGA) and were selected to balance the nutritional content, environmental impact, and ease of separating certain mixed-food items. The 2015-2020 DGA recommend consuming a meal pattern that includes five main food groups: grains, fruits, vegetables, proteins, and dairy.[48] Each food group provides a unique set of nutrients and also impacts the environment differently.[48,66] For example, animal proteins and dairy are far more resource intensive than fruits and vegetables, which are slightly

more resource intensive to produce than sugars and staple crops such as wheat, rice and other grains.[66]

Additionally, we considered that many foods served in the dining hall facility were recipes including a combination of items belonging to multiple food groups, and we evaluated the feasibility of separating these food items. For example, “sausage pesto pasta” included an animal protein of sausage, a grain of white flour pasta, and a pesto sauce.

For the present study, six food groups were determined and coded as; refined starch and added sugars, fruits and vegetables, dairy, animal proteins and fish, plant-based proteins, and whole grains. Unlike the 2015-2020 dietary guidelines, fruits and vegetable groups were combined and plant-based protein and whole grains were created and collected separately. This is because the production of plant-based proteins are much less resource intensive and release fewer greenhouse gas emissions than animal proteins.[66] Similarly, whole grains are more nutrient dense than starch and refined grains with a higher quantity of iron, dietary fiber and B-vitamins.[48] All plate waste was separated as accurately as possible and collected in the appropriated food groups. Beverages other than milk and orange juice were not measured as it would have been difficult to assign them to a proper food group. Additionally, nonedible items such as fruit peels, animal bones, tea bags and paper products were also not monitored in this study. Instead, they were collected and composted via the University's composting system.

4.2.4 Analysis of foods offered using the dining services food production records

Student plate waste quantities were summarized and the mass of plate waste from each food group was calculated. The mean weight of plate waste from each food group

were compared to the volume of food served and used to estimate the nutritional value and the greenhouse gas emissions associated with plate waste. To compare food served versus student plate waste, the university dining services food production records were used. The food production records provided a list of all food offered in the campus dining hall facility, the portion size of each item (provided as a weight) and the number of servings offered each day.

For each food item listed on the campus food production records, a representative food was matched from the SR-28 database, resulting in 161 SR-28 food codes; 49 food codes represented the starch and added sugars options offered in the dining hall facility, 47 food codes represented the available fruit and vegetable options, 13 food codes represented dairy options, 11 food codes represented the plant-based protein options, 33 food codes represented the animal protein and fish options, and 8 food codes represented the whole grain options offered. Combination food items and recipes listed on the food production records were included by individual foods item. For example, listed on the campus food production records was, "*Red Beans with Rice (spicy)*." This food was matched with two individual SR-28 food codes including; *1) Beans, kidney, red, mature seeds, cooked, boiled with salt (SR-28 code:16033), and 2) Rice, white, long-grain, regular, enriched, cooked (SR-28 Code: 20045).* A codebook with descriptions of the 161 SR-28 food codes used to represent the foods offered in the campus dining hall facility are included as Table 2 in the Appendix.

The weight of all food items served in the dining hall were aggregated by food group and the total volume of each food group was summed. To calculate the proportion of food

served that was discarded as plate waste, the volume of food served were compared to the volume of student plate waste observed in this study.

4.2.5 Estimates of the Nutrient Loss and Greenhouse Gas Emissions Associated with Plate Waste

The methods used to estimate the nutritional value and greenhouse gas emissions associated with plate waste were guided by two previous studies. One study contextualized the nutrient loss of food waste among consumers in the United States,[17] and the other contextualized the greenhouse gas emissions associated with the production of food that was otherwise discarded by consumers in the United States.[40]

Calculations of Nutrient Loss: To contextualize the nutritional value of plate waste, we used The National Nutrient Database for Standard Reference, Release 28, provided by the USDA. The database is the major source of food composition in the U.S. It contains data for 7,793 food items and up to 150 food components and provides the foundation of most food composition databases used in the public and private sectors.[67] To calculate the nutritional value of plate waste in the dining hall facility, we first had to understand the nutritional value of the food offered in the dining hall. Figure 3 provides a diagram of the data sources and methods used to calculate nutrient loss of plate waste. For each food item listed on the food production record, and its respective SR-28 food code, the nutrient composition was obtained for the volume offered in the dining hall facility. The nutrient composition for thirteen nutrient components was obtained including total energy (kcals), protein (g), vitamin A (IU), vitamin B-6 (µg), vitamin D (IU), folate (µg), calcium (mg), phosphorus (mg), potassium (mg), magnesium (mg), iron (mg), zinc (mg), and dietary fiber (g). These key nutrients of interest were selected as they are identified as the

nutrients that are under-consumed by food insecure populations; additionally, Vitamin D, calcium, dietary fiber and potassium are deemed as "nutrients of public health concern," and are under consumed by the general US population as identified by the 2015-2020 Dietary Guidelines for Americans.[48] All foods and nutrient components were aggregated by food group. The amount of each nutrient component was summed and represented in quantities of nutrient component per ounce of food offered. These estimates were then extrapolated to plate waste quantities observed in this study.

The Dietary Reference Intakes (DRI) are also presented to contextualize the nutritional value of plate waste.[26] The DRI of interest in this study refers to the age group 19 to 30 years, which is most comparable to "young adults" of university attending age. For energy, 2,000 calories per day was used as a recommended intake.

Calculations of the Greenhouse Gas Emissions : To estimate the greenhouse gas emissions (GHGE) associated with student plate waste, we adapted the GHGE estimates provided by Heller & Keoleian, 2014, in the table "Food Availability & Losses and Estimated Greenhouse Gas Emissions."[24] The table provides a compilation of a meta-analysis of literature investigating the GHGE associated with the production of various foods based on a life-cycle framework (from farm to fork). This table is included in the appendix as Table 3. In adapting this table, the GHGE emissions associated with each food item were aggregated by their respective food group and the average GHGE was calculated, represented as kg-CO2-equivalents. To calculate the GHGE associated with student plate waste, these estimates were extrapolated to the total volume of student plate waste observed in this study.

As described above, all estimates of the nutritional value and GHGE were calculated by food group. To determine the contribution of each food group to the total nutrient loss and greenhouse gas emissions estimated in this study, we further calculated the proportion of each food group to the total amount of observed plate waste.

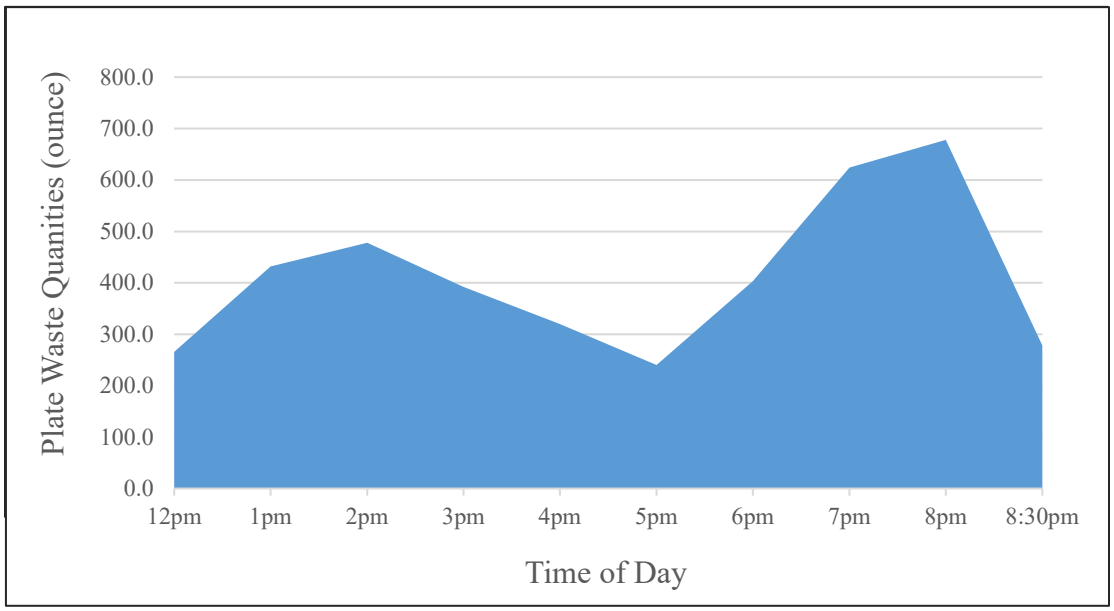
4.3 Results

4.3.1 Plate Waste Quantification and Production Patterns

Daily plate waste collected from one university dining hall ranged from 3328 - 4960 ounces, with an average of 4,113 ounces (257.4 lbs. ± 14.3). Considering an average of 2,026 student meals per day were served in this dining hall, this is the equivalent of 2.03 ounces (57.5 g) of edible plate waste for every student meal served.

When compared to the amount of food offered in the campus dining hall, student plate waste was estimated to be 11% of all food offered in the university dining hall facility. Plate waste was generated throughout the day with the highest quantities of plate waste were observed from 12:30 to 2:30 pm and 6 to 8 pm, representing typical meal-time hours of lunch and dinner (See Figure 4). This is likely due to more students dining during these hours since the meal options remained consistent throughout the day.

Figure 4. Frequency of Student Plate Waste Volumes Throughout the Day



4.3.2 Food Served Versus Student Plate Waste in the University Dining Hall

Using the campus food production records, we determined the volume of food options served in the dining hall. Foods served in the highest proportions were starch and added sugars options (35%), animal protein and fish options (31%), and fruit and vegetables options (19%). whole grains and plant-based protein options were offered daily, however in the smallest proportions, providing 3% and 4%, respectively, of the daily food choices.

We also determined the volume of student plate waste. The volume of student plate waste observed at the highest proportion were from starches and added sugars (46.4%), fruits and vegetables (24%), and animal proteins and fish (18%). This estimate, however, is incomplete to understand the food groups that are more frequently thrown away by students, until compared to the volume of each food group served.

We determined the proportion of the food served that was discarded as student plate waste (Table 4). The food groups that were discarded at the highest proportions of what was served included starch and added sugar options (14%), fruits and vegetable options (14%) and whole grain options (12%). This is interpreted as 14% of all starch and added sugar foods offered in the dining hall facility were thrown away as student plate waste. Plant-based proteins (5%) and animal protein and fish (6%) were discarded at the smallest proportions of what was served in the dining hall.

Table 4. Food Served Versus Student Plate Waste in the University Dining Hall

	Starch & Added Sugars	Fruits & Veggies	Dairy	Animal Proteins & Fish	Plant-Based Proteins	Whole Grains	Total
Food Served (oz)	13424	7110	2976	11990	1501	1094	38096
Student Plate Waste (oz)	1910	983	295	726	70	129	4113
Food served by food group (%)	35%	19%	8%	31%	4%	3%	100%
Student plate waste by food group (%)	46%	24%	7%	18%	2%	3%	100%
Proportion of food served that is discarded as plate waste (%)	14%	14%	10%	6%	5%	12%	11%

4.3.3 Nutritional and Environmental Value of Student Plate Waste

Plate waste from each student meal contributed to a loss of 100 calories, 5.5 grams of protein, 1.1 grams of dietary fiber, 46 mg calcium, 0.8 mg iron, 13.4 mg magnesium, 79 mg phosphorus, 0.6 mg zinc, 120 mg potassium, 122 µq-RAE Vitamin A, 0.1 µq Vitamin D, 0.15 mg Vitamin B-6 and 33.5 µq folate (see Table 5). The value of this nutrition is contextualized with reference to the US Dietary Reference Intakes (DRI), 19 – 30 years old.

Plate waste from each student meal also contributed to 0.18 kg-CO2-eq. of greenhouse gas emissions (see Table 6). Assuming students eat three meals a day, this is the equivalent of 0.53 kg-C02-eq per student per day. The food groups contributing the most to the estimated greenhouse gas emissions included animal proteins (56%), starch and added sugars (22%) and Dairy (11%). Whole grains and plant-based proteins contributed negligible amounts, respectively only 0.6% and 0.6%.

Table 5. Nutritional Value of Student Plate Waste

	Nutrient Loss		Daily Dietary Reference Intakes (DRI)	
			(RDA[c] or AI[d]) Age 19 - 30 y	
	Per Student Meal	Per Student/Day	Men DRI (% DRI[e])	Women DRI (% DRI[e])
Energy, Macronutrients, and Dietary Fiber				
Energy (kcal)	100	299	2000 (15%)	2000 (15%)
Protein (g)	5.5	16.6	56 (30%)	46 (36%)
Dietary Fiber (g) [a,b]	1.1	3.3	38 (9%)	25 (13%)
Minerals				
Calcium (mg) [a,b]	46	138	1000 (14%)	1000 (14%)
Iron (mg) [a]	0.8	2.5	8 (31%)	18 (14%)
Magnesium (mg) [a]	13.4	40.3	400 (10%)	310 (13%)
Phosphorus (mg) [a]	79	334	700 (48%)	700 (48%)
Zinc (mg) [a]	0.6	2.4	11 (22%)	8 (30%)
Potassium (mg) [a,b]	120	237	3400 (7%)	2600 (9%)
Vitamins				
Vitamin A (ug RAE) [a]	122	365	900 (41%)	700 (52%)
Vitamin D (ug) [a,b]	0.1	0.3	15 (2%)	15 (2%)
Vitamin B-6 (mg) [a]	0.15	0.45	1.3 (35%)	1.3 (35%)
Folate (ug) [a]	33.5	101	400 (25%)	400 (25%)

[a] Under-consumed nutrients
[b] Nutrients of public health concern
[c] RDA = Recommended Dietary Allowance
[d] AI = Adequate Intake
[e] (% DRI) = % DRI of each nutrient component discarded as student plate waste per student per day

Table 6. Greenhouse Gas Emissions (GHGE) Associated with Student Plate Waste

	Starch & Added Sugar	Fruits & Veggies	Dairy	Plant-Based Proteins	Animal Proteins & Fish	Whole Grains	Total
Avg. GHGE of food group (kg-CO2-eq/kg) **Keller & Keoleain 2014*	1.67	0.78	4.3	1.2	10.1	0.5	18.4
Vol. Plate Waste (kg)	54.2	27.9	8.4	2.0	20.6	3.7	116.8
GHGE associated with plate waste (kg-CO2-eq)[a]	90.5	21.8	36.1	2.4	208.1	1.9	360.8
GHGE per meal served (kg-CO2-eq)[b]	0.04	0.01	0.02	0.001	0.10	0.001	0.18
Proportion of GHGE per food group (%)	22%	5.6%	11.1%	0.6%	55.6%	0.6%	100.0%

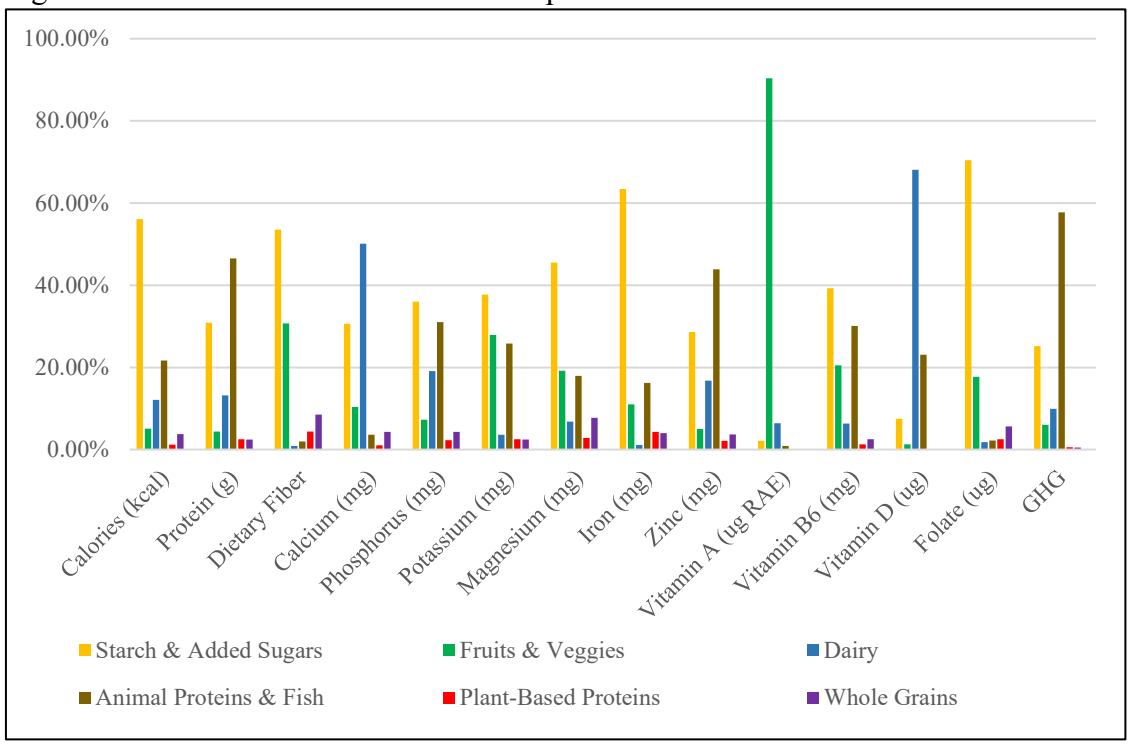
[a]An estimate of the greenhouse gas emissions contained in student plate waste; (Avg. GHGE from Table S1) x (Plate Waste Quantities (kg))
[b]An estimate of the greenhouse gas emissions contained in student plate waste per meal offered in a university dining hall facility; (GHGE contained in student plate waste) / (2026 meals served per day)

4.3.4 Nutrient Loss and Greenhouse Gas Emissions by Food Subcategory

We examined the contribution of each food group to both the nutritional value and the greenhouse gas emissions associated with plate waste (see Figure 5). Starch and added sugars contributed to substantial loss of almost all nutrients (~30 – 70%), except for Vitamin A (~3%) and vitamin D (~8%); and were also the second leading contributor to greenhouse gas emissions produced by food that was never consumed. Fruits and vegetable waste accounted for >90% of the Vitamin A lost and was also a source of dietary fiber (31%), potassium (28%), and magnesium (19%). Additionally, animal proteins and fish contributed to the loss of protein (47%), phosphorus (31%), iron (16%) and zinc (44%); and dairy products to calcium (50%) and vitamin D (68%). Animal proteins and fish were also the largest contributors to the greenhouse gas emissions, and dairy was the third highest contributor. Whole grain items and plant-based proteins did not contribute substantially to nutrient losses or greenhouse gas emissions (~0-7%). It is

likely this is due to only a very small volume of plate waste observed from each of these food groups.

Figure 5. Contribution of Each Food Group to the Hidden Value of Student Plate Waste



4.4 Discussion

The purpose of this study was to comprehensively quantify student plate waste in the university setting, to identify plate waste production patterns among students and to further put meaning into the quantities of plate waste by contextualizing the nutritional and environmental value.

Student plate waste was found to range from 5% to 14% of all food served in the university dining hall facility, depending on food group. In the U.S., plate waste studies have primarily been conducted among children in schools participating in the National School Lunch Program to understand how well the school nutrition program has been

accepted by primary and secondary students.[88,89,35] Plate waste estimates have been observed as high as 45.3% of total food served to these younger students.[89] However, these estimates may not translate well to an adult population, as the primary and secondary school settings generally offer meals with pre-determined items and portion sizes, as opposed to self-selection by the individual. Few plate waste estimates are available in the university setting.

A study conducted at the University of Switzerland found food waste accounted for 10.73% of the total food.[65] However, this estimate included plate waste in addition to storage waste, preparation losses, and losses from food remaining from the buffet/serving stations after meals. Comparatively, our estimate only included plate waste and was much higher. This difference may be because we observed plate waste at an all-you-can eat, buffet style dining where students were unable to "take-away" leftovers, two factors that have been associated with increased plate waste among students.[10,27,28] Another study that investigated food waste among fifty-one foodservice outlets in Finland including university canteens in addition to restaurants, and workplaces, found plate waste to contribute up to 9.5% of the food served, an estimate which aligns better with our findings.[27] Further, a study at Kansas State University observed student plate waste volumes to be 57 g/meal,[7] an estimate which also aligns with our study. We found the volume of student plate waste to be 57.5g (2.03 oz) of edible food per student meal. The study further found that among students dining in the dining hall, about 40% of them had zero-plate waste,[11] and very few left edible wastes in excess of 150g.[7,65]

Currently, the reasons behind plate waste behaviors among students is not well understood. It has been suggested that students may unknowingly select more food than

they can eat,[12] or discard food because they dislike the taste,[39] or further, deem the food as "less valuable" due to being a side dish like rice or mixed vegetables, fast food options like french-fries and pizza or perceived as otherwise "inexpensive."[11] In this study, we determined foods that are commonly thrown away as plate waste. These include starch and added sugar options such as pasta, pizza, and cake; fruits and vegetables, both raw and cooked; and whole grains options such as brown rice, quinoa and whole wheat bread or pasta. To help reduce waste of these food items, it has been suggested to offer samples of foods that are commonly wasted, and of new menu items that students may not have prior experience.[12] It has also been suggested to reduce overall selection of foods by decreasing the variety of items served,[92] pre-portioning a desired serving size,[75] and removing trays from dining halls to prevent overloading the trays with food.[84]

Further, we put meaning into the volume of plate waste observed by contextualizing the nutrition and environmental value of the waste. Comparative studies in this setting are lacking, however, some national estimates are available. In the United States, consumers are suggested to waste 1217 kcal, 33 g of protein, 5.9 g dietary fiber, 1.7 μq vitamin D, 286 mg calcium, and 880 mg potassium, per person per day.[17] Additionally, consumer food waste is also suggested to account for 1.4 kg-CO2-equivalents per person per day.[40] These estimates are much higher than contextualized in our study, however this was expected as these estimates account for plate waste in addition to waste that results from over-preparation, production, and spoilage. However, our estimates still provide meaningful insight into the potential of food waste reduction in this setting.

In fact, to the best of our knowledge, this is the first study to use university dining food production records to identify plate waste production patterns among students, and

to further contextualize the value of student plate waste. We also propose insights into the best practices for investigating the volume of plate waste in a university dining hall operating an all you can eat buffet style food services. Student plate waste was found to be continuously generated throughout the entire day, with larger volumes observed during meal-time hours when the rate of students dining increased substantially. This suggest that for accurate estimates, plate waste should be observed throughout the entire food service, rather than only at meal-time hours. It also suggested that larger dining halls, and dining halls that receive more traffic, will likely generate larger volumes of student plate waste.

Our study did have some limitations. First, the greenhouse gas emissions adapted in this study were related to the production of the food and does not consider the methane gas that is released as food decomposes in the landfill. Methane gas is twenty-five times more potent than carbon dioxide,[3,5] so our estimate likely underrepresents the true GHGE associated student plate waste. Additionally, the 161 SR-28 foods used in this study generally correspond to basic ingredients, encompassing cooking methods such as boiled and fried, however were used to represent all varieties of food served in the university dining hall. Further, it is important to note that people eat food, and not nutrients, and although our estimations are meaningful, we do not know how these nutrients translate into specific foods, and/or meals. Lastly, we collected our food waste data in the dining room, where data collection activities were visible to students. This may have introduced some bias, where students may have changed their food waste behaviors due to recognizing that we were collecting their food scraps.

4.4.1 Conclusion

Our study provides evidence that student plate waste in the university setting is a significant problem with enormous potential in food waste reduction initiatives. In 2015, the EPA and the USDA issued the US Food Waste Challenge to call for a 50% reduction in food waste by 2030.[32] Targeting food waste reduction initiatives in the setting can help to reduce the stress on our environment caused by greenhouse gas emissions and make accessible more nutritious food for vulnerable populations.

Given the significant quantities of student plate waste, future studies should evaluate the effectiveness of waste reduction strategies in the university dining hall facility, with strategies targeting both consumer behavior and structural change of the dining hall environment. As buffet-style, all-you-can eat food services are commonly associated with more food waste,[27,28] it has also suggested to instead provide al-la-carte or cook to order, services. However, the anytime dining food service style was implemented as a strategy to increase the availability and accessibility of food to students who experience food insecurity, a phenomenon that is increasingly prevalent on university campuses. Therefore, there is a need to discuss plate waste reduction initiatives that may simultaneously address food insecurity. Future studies should also aim to understand the drivers that influence food waste behaviors among students and the barriers that impede food waste reduction in this setting.

Lastly, university dining is progressively evolving, offering a greater amount of choices, featuring more fresh food options and modern cooking styles. As dining services transition to more sustainable menus, more variety of plant-based foods and seasonal produce will be included in recipes. Students are, in turn, also increasingly expressing a

higher demand for high quality, and locally sourced options. As campus dining hall menus change, it is imperative to continue to conduct routine food waste audits to identify areas within the system to intervene.

Chapter 5 (Paper 2): The Psycho-Social and Behavioral Drivers Influencing Food Waste Behavior Among College Students

5.1 Introduction

Every year, one-third of all food produced for human consumption goes uneaten due to food loss and waste. Indeed, wasted food has significant impact on the environment and the nutritional status of populations.[3,97] It represents unnecessary greenhouse gas emissions and a loss of essential nutrition that could have been used, otherwise, to feed populations.

Food loss and waste occurs along the entire food supply chain, however in the U.S this wasted food is typically "food waste," or the food that is thrown away due to the decisions and actions occurring among retailers, food service providers and consumers.[95,96] This waste arises from food that is leftover on consumer plates after a meal; food that is thrown away due to spoilage, over-production and over-purchasing; food that is rejected due to altered cosmetic appearance, etc.[3] Food waste reduction initiatives targeting behavioral change consumers have been suggested to be one of the most effective ways to reduce food waste.[3,5,93,97]

Several studies targeting consumer households have aimed to investigate the attitudes and beliefs related to food waste.[20-24] Generally, consumers have reported to have negative attitudes towards food waste, often feeling bad about throwing away food.[7] This may be a result of the environmental, social and financial consequences of food waste that are increasingly being recognized among consumers.[3,24] Health concerns have also been related to food waste.[23,38] Consumers who report to have more criteria for assessing the freshness of food, such as use-by dates, length of time in the refrigerator,

etc. were found to throw away more food.[38] Additionally, those who report being more health conscious tend to purchase a variety of perishable foods, which often are discarded if not all eaten.[23] Further, consumers who desire to provide an abundance of variety and healthy food for families and guests, admittedly report to purchasing and preparing too much food than can be eaten.[23,24] Having a lack knowledge of food storage, food safety and food labeling, and not having the skills to use leftover food and recreate it into different meals has also been associated with unnecessary food waste.[20, 22-23]

Studies among households have provided some insight into the determinants that motivate or impede food waste behaviors among consumers. However, there is a gap in the literature for investigating food waste behaviors among young adults attending university. This is critical as fundamentally, age has been negatively associated with quantities of food waste,[20,22-23] suggesting that young adults waste higher quantities of food. This observed phenomenon is suggested to be a factor of the transition from home to university where young adults are required to reorient their own food related activities and food waste behaviors in a new food environment.[90] Identifying key drivers influencing food waste behaviors and understanding how these factors relate to the volume of food wasted among university students are crucial to prevent and manage food waste among this population.

The purpose of this paper is to identify the food waste-related psychosocial factors and behavioral activities influencing food waste among attending university. We further aim to investigate the relationship of these drivers to the perceived volume of wasted food among university students. We hope to use this knowledge to identify the most

critical factors that should be targeted in food waste reduction initiatives among university students.

5.2 Methods

5.2.1 Theoretical Framework

The Theory of Planned Behavior (TPB) framework has recently been investigated as a model to explain food waste behaviors at the individual level.[21,24,98] The major assumption of this framework is that an individual's intention to engage in a behavior is the greatest predictor of observed behavior;[99] and that behavioral intention is influenced by personal attitudes, or the individuals concern of the likely consequences of the behavior, subjective norms, and perceived behavioral control. Outcomes of such studies have confirmed that a higher intention to reduce food waste is significantly,[24] or somewhat-[21] related to a smaller amount of self-reported food waste, and that perceived behavioral control, or the individuals' belief that they can control their behavior, is the strongest predictor of an individual's intention to reduce food waste.[21,24] Exploratory studies have also found some consumers report social norms to have a positive influence on one's' motivation to reduce food waste,[23] however, no statistically significant associations have been observed.[22,24] It is suggested that this may be because throwing away food is not easily visible to our peers and thus their expectations do not impact individual food waste behaviors.[20] Additionally, in an effort to better explain food waste behaviors among consumers, recent studies have also begun to bring food-related activities such as menu planning, food shopping and preparing meals into the TPB framework.[21,22,24] The present study was guided by the Theory of Planned Behavior

framework and extended to include food-related activities identified in the literature that may help explain food waste behaviors among university students.

5.2.2 Study Setting and Participant Recruitment

This study took place at a large, public, and diverse university of approximately 40,521 students of which 74% are undergraduate and 26% are graduate students. The student body consists of slightly more males (53%) than females (47%), and slightly less than 50% are of white race/ethnicity. Students have access to several food service outlets on campus, including three, dining hall facilities, two, full-service restaurants, a food court and multiple campus cafes located around campus.

Between September and November 2018, and an additional 4 weeks from February 4th to March 5th, 2019, a behavioral survey was distributed to students via email by various listserv around campus. The survey was shared over several academic listserv including college, department and classroom emailing lists, the campus recreation center listserv, various sporting, and extra-curricular listserv, and over campus Greek life listserv. Students, 18 years or older and enrolled for credit at the university were eligible to participate. Enrollment was voluntary. This research was approved by the Institutional Review Board at the University of Maryland.

Data were collected by means of a web-based survey developed in the Qualtrics software. A total of 338 questionnaires were used for analysis.

5.2.3 Measures

Socio-demographics such as age, gender, race, year of study, living situation (on or off campus), employment status, and dietary restrictions or preferences were assessed.

The psychosocial drivers and food related activities including in this study are explained below and items are shown in Table 7 in the Appendix.

Self-reported food waste behaviors (α = 0.77) were measured using a 5-item scale, which was developed and tested by Stefan et al., 2013,[22] and has been used among consumer households. Items referred to food waste in general and in specific subcategories of food. Subcategories were defined using guidelines for a healthy and balanced dietary pattern, established by the 2015 – 2020 Dietary Guidelines for Americans and included starch and added sugar, fruits and vegetables, dairy, animal proteins and fish, plant-based protein and whole grains.[48]

The psychosocial drivers influencing food waste behaviors among students were assessed using an extensive model of constructs. Several were guided by the Theory of Planned Behavior framework,[99] and tested by Visschers et al., 2016,[24] including intention to reduce food waste (α = 0.853), a 4-item scale measuring an individual's intention to engage in food waste reduction behaviors with items such as "*I try to throw away only very little amounts of food*;" personal attitudes (α = 0.705), a 2-item scale measuring personal concerns relating to food waste with items such as "*It is immoral to discard foods while others in the world are starving*;" financial attitudes (α = 0.641), a 4-item scale measuring financial concerns relating to food waste with items such as, "*I think wasting food in a waste of money*;" and perceived behavioral control (α = 0.711), a 6-item scale measuring an individual's perception that they can control how much food they waste with items such as "*I find it difficult to purchase foods in such a way that all food I purchase is eaten*," and "*other roommates make it impossible for me to reduce the amount of food that I throw away*." Additionally included was environmental attitudes

(α = 0.757), a scale developed and tested by Werf et al., 2019,[98] and including 3-items measuring environmental concerns related to food waste with items such as "*I believe that leaving uneaten food on my plate has a negative effect on the environment*."

Several additional constructs developed and tested by Visschers et al., 2016,[24] were included; personal norms (α = 0.724) a two-item scale measuring an individual's feelings about food waste with items such as "*I feel bad when I throw away food*;" perceived health risks of consuming leftover foods (α = 0.612) a 4-item scale with items such as "*I am worried that eating leftovers may damage my health*;" the good provider identity (α = 0.628), a 4-item scale measuring the desire to provide healthy and abundant foods for families and guests, with items such as "*I regularly buy fresh products, although I know that not all of them will be eaten*,' and "*when I am expecting guests, I like to buy more food than is necessary because I am a generous host*."

Food- related activities influencing food waste behaviors were also included using several constructs developed and tested by Stefan et al., 2013,[22] and Stancu et al., 2016.[21] Food shopping activities (α = 0.66) were assessed using a 2-item scale with items such as "*I often buy unintended food products when shopping*;" food planning activities (α = 0.514), a two-item scale with items such as "*before I go grocery shopping, I check my food inventory and make a list of what I need*;" leftover reuse activities (α = 0.534), a two-item scale measuring an individual's ability and willingness to reuse leftover food with items such as "*I store my leftovers correctly so they will last until I am ready to eat them again;*" and self-efficacy of food management skills (α = 0.791), a 6-item scale measuring an individual's confidence that they can effectively manage their food related activities to avoid food waste with items such as "*I can plan my meals and use the food in*

my refrigerator and pantries before buying new food items," and "*I have the skills needed to cook and prepare meals from raw and fresh ingredients*." These constructs were all rated using a 5-point likert scale ("strongly disagree" = 1 to "strongly agree" = 5). Items included in the perceived behavioral control construct were reverse coded, as well as two items from financial attitudes and three items from perceived health risk. Higher scores corresponded to a higher agreement with each statement.

Our model was further extended with three additional construct (Table 8 in Appendix 5), including two, 3-item scales measuring knowledge related to food waste, respectively knowledge of use-by-dates (M=2.06, SD= ±0.58) with item such as "*Choose whether you agree or disagree…The use-by date is interpreted as the date that food products can become a health risk if they are consumed after that date*;" and knowledge of food storage (M=2.36, SD= ±0.58), with items such as "*Choose whether you agree or disagree… Fruits excrete gas during storage, which keeps vegetables fresh longer. Fruits and vegetables should therefore be stored together*."

Additionally, a 5-item awareness scale[43] ($\alpha = 0.67$) such as "*In the past year, have you seen or heard anything in the news, social media or elsewhere about food expirations dates?" was used to measure students' general awareness of food waste problem.* A score of one was assigned to each affirmative response, and summed scores ranged from 0-5. Higher summed scores indicated a higher knowledge related to food waste or a higher awareness of the food waste problem. Table 8 in the Appendix shows the scales used for awareness of the food waste problem, knowledge of use-by dates and knowledge of proper food storage.

This questionnaire also included questions specific to the food-related activities of students enrolled in university. These questions, created by the research team, were guided by findings from previous literature.[7,11,39] Items included self-reported food purchasing behaviors, food selection in the university dining hall, and reasons for throwing away food both on and off campus.

5.2.4 Data Analysis

The data were analyzed using IBM SPSS, version 26. Descriptive statistics were used to assess baseline demographics. To deal with missing values, all scales were adjusted by imputing means for missing values, as the converted means and the unconverted (original) means remained the same, with changes reflected only in retaining the sample size (n=338).

The probability distribution of self-reported food waste was positively skewed. This was expected, as individuals have been found to under-report the amount of food they waste.[20] To normalize the distribution of this scale, we log-transformed the data, which moderately improved the skewness.[100-101] The log-transformed self-reported food waste was used in further analysis including correlation and regression analysis.

Pearson correlation coefficients were assessed to investigate associations among key study variables. Hierarchical linear regression was conducted to identify statistically significant predictors of the outcome variables, intention to reduce food waste and self-reported food waste. Three models were investigated. The first model consisted of several demographic variables including age, gender, living situation (on or off campus), year of education (1st or 2nd year, 3rd or 4th year, and 5th+), and employment status. The second model was extended with the addition of all psychosocial variables including: perceived

behavioral control, intention to reduce food waste (with self-reported food waste as the outcome variable), personal norms, attitudes (personal, financial and environmental), perceived health risk, the good provider identity, awareness of the food problem, knowledge of use-by dates, and knowledge of proper food storage. The third model was extended to include food related activities including food shopping, food planning, leftover reuse activities and self-efficacy for food management.

5.3 Results

5.3.1 Sample Characteristics

Most of the sample were white (63%) and female (77%), with more of respondents living-off campus (61%) than on-campus (39%). Most were undergraduate students; about 44% in their 1st or 2nd year, 41% in their 3rd or 4th year, and 15% in their 5^{th} + year. The average age of respondents was 21 years (range of 18 – 35 years). About half of the sample reported to be employed, and 32.2% reported to be food insecure. Greater than 50% of respondents also reported having a diet restriction or dietary preference, as listed in Table 9.

Table 9. Sample Characteristics

Variables	n (%) / m ±SD
Gender	
Male	78 (23%)
Female	257 (77%)
Race	
White	235 (63%)
African American/Black	34 (9%)
Hispanic/Latino/Spanish	28 (7%)
Asian	29 (19%)
Other/non-specific	6 (2%)
Age (range of 18 – 35 years)	21.29 ±3.55
Academic Year	
1^{st} or 2^{nd} year	149 (44%)

3rd or 4th year	140 (41%)
5th year+	49 (15%)
Employed Students	181 (53%)
Living Arrangement	
On campus with a dining plan	81 (24%)
On campus without a dining plan	51 (15%)
Off campus (alone) or with roommate/spouse	169 (50%)
Off campus with family or other relatives/family friends	34 (10%)
In a sorority/fraternity house	3 (1%)
Food Insecure	109 (33%)
Dietary restrictions or preferences	
Religious restrictions (ie. Kosher, Halal)	9 (3%)
Food allergies and/or intolerances, or health-related restriction	31 (9%)
Other/non-specific	31 (9%)
Limited animal product (ie. plant-based, vegetarian, pescatarian)	66 (19%)
None	209 (60%)

5.3.2 University Specific Food Related Activities Among Students

Table 10 presents the self-reported food related activities. Amongst our sample, 57% reported to purchasing food on campus at least once a week, and 38% reported to eating at the dining hall at least once a week. 62% of our sample reported to never eating in the university dining halls.

Students who reported eating at the dining hall, reported to selecting from an average of three separate food stations during their meals. The most popular reasons for selecting food items from more than one station included wanting to try more food, feeling hungry enough for more food, and feeling uncertain of whether they would like the food they selected. Students who selected "other" as a reason why they choose from more than one station often reported because they desired more of a variety of food to balance their meals.

We also asked students to indicate reasons for wasting food, both on campus and off campus. The top reasons students wasted food on campus included not liking the taste (27%) or quality of the food offered (18%) and having no place to store leftovers while

on campus (16%). The top reasons students wasted food off campus included preparing or purchasing too much (34%), not storing their food properly and allowing it to spoil (27%), and having no time for the food management skills that would prevent throwing out food (19%).

Table 10. University Specific Food Related Activities Among Students

Variables	n (%)/ m ±SD
Food purchasing while on campus	
Daily	21 (6%)
More than once a week or several	94 (28%)
Once a week	78 (23%)
Less than once a week or occasionally	110 (33%)
Never	35 (10%)
Eating at the dining hall during the week	
Never	211 (62%)
1 to 5 times	40 (12%)
6 to 10 times	28 (8%)
11+ times	59 (18%)
Ave. number of serving stations students select in the dining hall (range 0-7)	2.95 ±1.08
Reasons to select food items from more than one station	
I want to try more than one food	113 (41%)
I feel that I am hungry enough for more food	72 (26%)
I am not sure if I will like the taste of what I selected	52 (20%)
It is all included in the price of the meal	28 (10%)
Other reason	9 (3%)
Reasons for food waste on campus (in the dining hall)	
The food does not taste great (too oily, too salty, or not yummy)	182 (27%)
The food is not good quality	120 (18%)
There is no place to store leftovers on campus	112 (16%)
I am unaware of how much I select and get full before I can finish it all	90 (13%)
I do not have time to finish my meals in the dining hall	87 (12%)
I lost my appetite	73 (10%)
Other reason (explained in text)	30 (4%)
Reasons for food waste at home	
I purchased or prepared too much and could not finish it all	183 (34%)
I did not store the food properly and it was no longer edible	145 (27%)
I do not have time for the actions that would prevent throwing out food	99 (19%)
I do not have the cooking skills to create meals from leftovers or fresh/raw ingredients	58 (11%)
I only want to eat the freshest food	46 (9%)

5.3.3 Bivariate Correlation

The bivariate analysis revealed significant associations between self-reported food waste, the intention to reduce food waste and most other psychosocial drivers and food

related activities (Table 11). Personal and environmental attitudes relating to food waste, food planning activities and awareness of the food waste problem were not significantly associated with self-reported food waste, however they were significantly associated with the intention to reduce food waste ($p<0.01$). Knowledge of use-by dates was not significantly associated with either self-reported food waste or intention to reduce food waste. Knowledge of use-by dates was only significantly associated with perceived health risk of consuming leftover food. Intention to reduce food waste and perceived behavioral control revealed to be most strongly correlated to self-reported food waste ($p<0.001$). This indicated that having a higher intention to reduce food waste and a higher perceived behavioral control to reduce waste were associated with less amounts of self-reported food waste. The intention to reduce food waste was strongly and positively associated to self-efficacy for food management, personal norms relating to food waste, financial attitudes, and perceived behavioral control ($p<0.001$). Self-efficacy of food management was also strongly and positively associated with perceived behavioral control to reduce food waste, and leftover reuse activities ($p<0.001$). Personal norms relating to food waste were also strongly and positively associated with personal ($p=0.003$), financial($p<0.001$), and environmental attitudes($p<0.001$).

Table 11. Bivariate Pearson Correlation Coefficients Between All Psychosocial Driver and Food Related Activities

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Self-reported food waste	1															
2	Intention to reduce food waste	-.304**	1														
3	Perceived behavioral control	-.364**	.403**	1													
4	Personal norms related to food waste	-.155**	.507**	.189**	1												
5	Personal attitudes	-.102	.322**	.110*	.505**	1											
6	Financial attitudes	-.185**	.435**	.189**	.476**	.271**	1										
7	Environmental attitudes	-.097	.327**	.132*	.540**	.441**	.363**	1									
8	Perceived health risk	.265**	-.249**	-.302**	-.272**	-.130*	-.214**	-.261**	1								
9	The good provider identity	.232**	-.166**	-.301**	-.094	0.005	-.130*	-.08	.152**	1							
10	Self-efficacy for food management	-.219**	.551**	.499**	.311**	.192**	.290**	.274**	-.304**	-.062	1						
11	Food shopping activities	.202**	-.117*	.326**	.072	0.061	-.069	.003	0.098	.329**	-.201**	1					
12	Food planning activities	-.071	.246**	.238**	.072	0.024	.150**	.145**	-.105	.016	.316**	-.217**	1				
13	Leftover reuse activities	-.120*	.325**	.321**	.190**	.148**	.162**	.130*	-.200**	-.062	.418**	-.08	.255**	1			
14	awareness of the food waste problem	-.056	.159**	.152**	.183**	0.103	.160**	.137*	-.078	-.001	.178**	-.005	.122*	.108*	1		
15	Knowledge of use-by dates	-.052	.044	0.073	.059	0.042	.129*	.039	-.235**	-.056	.056	-.027	-.068	.006	.065	1	
16	Knowledge of proper food storage	-.147**	.141**	0.056	.109*	0.046	.112*	.112*	-.170**	-.078	.094	0.025	0.098	.025	.101	.053	1

**Correlation is significant at $\alpha < 0.01$ level (2-tail)
*Correlation is significant at alpha < 0.05 level (2-tail)

5.3.4 Hierarchical Linear Regression

Table 12 shows the results of the hierarchical linear regression on self-reported food waste. The regression revealed a good fit for model two and model three. Model three, including all demographic predictors, psychosocial drivers and food related activities explained 23% of the amount of food waste self-reported by students and demonstrated the best model fit. Intention to reduce food waste and perceived behavioral control to avoid food waste were both significantly associated with less amounts of self-reported food waste. Perceived health risk was significantly associated with higher amounts of self-reported food waste. Students who worried that consuming leftovers or food past its use-by date would be harmful to their health reported higher amounts of food waste. The addition of food related activities revealed knowledge of proper food storage to be somewhat associated with less amount of self-reported food waste, and food shopping activities to be somewhat associated with higher amounts of self-reported food waste. Students who reported to buying unintended items when food shopping or to purchasing bulk packages also reported to wasting more food.

Table 12. Hierarchical linear regression analysis on self-reported food waste

	Model 1 R^2 = 0.03 F(6,331) = 1.684, p=0.124				Model 2 R^2 = 0.217 F(17,320) = 5.211, p<0.001				Model 3 R^2 = 0.232 F(21,316) = 4.541, p<0.001			
	B	SE (*B*)	β	*p*	*B*	SE (*B*)	β	*p*	*B*	SE (*B*)	β	*p*
(Constant)	.365	.064		.000	.543	.116		.000	.467	.124		.000
Age	-.006	.003	-.136	.590	-.004	.003	-.830	.210	-.004	.003	-.104	.123
Year (3rd or 4th)	-.031	.021	-.099	.151	-.250	.020	-.080	.209	-.029	.020	-.092	.150
Year (5th+)	-.010	.032	-.024	.747	-.007	.030	-.016	.818	-.013	.030	-.031	.653
Gender	.006	.020	.015	.781	.001	.019	.002	.974	-.009	.019	-.025	.640
Living situation	.007	.023	.021	.774	.003	.021	.010	.881	.007	.021	.023	.728
Employment	.007	.018	.023	.699	-.002	.017	-.005	.927	.002	.017	.008	.887
Intention to reduce food waste					-.036	.015	-.150	.020**	-.047	.017	-.193	.006**
Perceived behavioral control					-.045	.013	-.214	.000***	-.049	.014	-.229	.000***
Personal Norms					.006	.013	.034	.629	.004	.013	.022	.756
Personal attitudes					-.007	.010	-.043	.474	-.007	.010	-.410	.497
Financial attitudes					-.011	.013	-.049	.426	-.009	.013	-.041	.499
Environmental attitudes					.009	.011	.122	.420	.007	.011	.040	.525
Perceived health risk					.026	.012	.125	.030**	.028	.012	.134	.020**
The good provider identity					.025	.011	.122	.022**	.016	.011	.078	.164
Awareness of the food waste problem					.001	.006	.010	.843	.000	.006	-.003	.952
Knowledge of use-by dates					.007	.014	.027	.600	.010	.014	.038	.464
Knowledge of proper food storage					-.021	.014	-.081	.117	-.023	.014	-.085	.098*
Food shopping activities									.016	.008	.108	.062*
Food planning activities									.013	.010	.075	.192
Leftover reuse activities									.008	.014	.031	.584
Self-efficacy for food management									.016	.016	.070	.310

***p<0.01, **p<0.05, *p<0.1

Table 13 shows the results of the hierarchical linear regression on the intention to reduce food waste. The regression revealed a good fit for model two and model three. Model three demonstrated the best fit and explained ~50% of students' intention to reduce food waste. Additionally, when extended with the food related activities, the model significantly better explained student food waste behaviors ($p<0.001$).

In model one, students who reported to be employed were somewhat associated with a lower intention to reduce food waste. When the model was extended with the psychosocial drivers and the food related activities, employment status was no longer associated with intention to reduce food waste. Perceived behavioral control, personal norms and financial attitudes were all significantly associated with a higher intention to reduce food waste. The inclusion of food related activities revealed age and self-efficacy for food management to also be significantly associated with the intention to reduce food waste. Age was negatively associated with the intention to reduce food waste, demonstrating that younger students had a higher intention to reduce their food waste. Having a higher self-efficacy for food management was associated with a higher intention to reduce food waste. Personal attitudes and food planning activities were found to be somewhat associated with intention to reduce food waste. Students with higher personal concerns relating to food waste, and students who reported to engage in menu planning and food inventory before grocery shopping were associated with a higher intention to reduce food waste. The good provider identity was also somewhat associated with the intention to reduce food waste, demonstrating that students who desired to be seen as a good host/provider or desired for family members or guests that always have a variety of healthy foods also had a lower intention to reduce food waste.

Table 13. Hierarchical linear regression analysis on intention to reduce food waste

	Model 1 R^2 = 0.018 F(6,331) = 1.033, p<0.404				Model 2 R^2 = 0.404 F(16,321) = 13.6, p<0.001				Model 3 R^2 = 0.498 F(20,320) = 15.7, p<0.001			
	B	SE (*B*)	β	*p*	*B*	SE (*B*)	β	*p*	*B*	SE (*B*)	β	*p*
(Constant)	4.436	.264		.000	1.873	.406		.000	1.283	.407		.002
Age	-.001	.013	-.008	.912	-.012	.010	-.065	.258	-.021	.010	-.118	.028**
Year (3rd or 4th)	.071	.089	.055	.423	.053	.071	.041	.455	.037	.066	.029	.580
Year (5th+)	-.036	.133	-.020	.787	.012	.107	.007	.913	-.026	.099	-.015	.789
Gender	.036	.083	.024	.665	.009	.068	.006	.900	-.027	.064	-.018	.675
Living situation	.011	.095	.008	.912	.045	.076	.035	.552	.058	.070	.044	.413
Employment	-.141	.075	-.111	.059*	-.016	.061	-.013	.793	-.005	.057	-.004	.936
Perceived behavioral control					.257	.043	.292	.000***	.105	.045	.119	.020**
Personal Norms					.229	.045	.301	.000***	.202	.042	.266	.000***
Personal attitudes					.057	.036	.083	.109	.057	.033	.083	.087*
Financial attitudes					.181	.047	.200	.000***	.147	.044	.162	.001***
Environmental attitudes					-.005	.041	-.006	.910	-.035	.038	-.048	.351
Perceived health risk					-.012	.042	-.014	.778	.023	.039	.028	.552
The good provider identity					-.023	.039	-.028	.551	-.067	.038	-.079	.079*
Awareness of the food waste problem					.005	.020	.011	.813	-.010	.019	-.023	.590
Knowledge of use-by dates					-.033	.049	-.030	.501	-.007	.046	-.006	.886
Knowledge of proper food storage					.066	.049	.060	.176	.060	.045	.055	.185
Food shopping activities									.010	.028	.016	.726
Food planning activities									.058	.033	.080	.082*
Leftover reuse activities									.070	.048	.066	.148
Self-efficacy for food management									.308	.049	.330	.000***

***p<0.01, **p<0.05, *p<0.1

5.3.5 Suggested Strategies for Food Waste Reduction

We also asked student to indicate which suggested strategies they believed would be most effective in reducing food waste on campus (Table 14). The strategies students perceived to be most effective included recovering surplus food items that would otherwise go to waste and make them more available to students who do not have sufficient access to enough food or to healthy and nutritious food (44%), to provide appropriate portion size of food items in the dining hall (15%), and to implement effective signage to raise awareness of the food waste issue (13%). We also asked students which kinds of food they would like to see served more often in the dining hall and food items they would like to see served less. Students reported wanted to have more options of plant-based food items including a greater variety of fruits and vegetables (38%), having more locally grown and fresh prepared food items (28%), and having a greater variety of choice, notably of cultural cuisines (13%). Students reported wanting to have less of fried and high fat foods (45%), overly processed or poorly prepared foods (28%), and having less animal products including meat and dairy options (16%).

Table 14. Suggested Strategies for Food Waste Reduction in the University Setting

	% of sample
Strategies that students feel would be MOST effective for reducing food waste on campus	
Elimination of the all-you-can-eat dining	7%
Campaigning during new-student orientation week	10%
Having consistency in menus and the taste of food items	11%
Implementing effective signage to raise awareness of the food waste issue	13%
Providing appropriate portion sizes of food items	15%
Recovering surplus food items	44%
The kinds of foods student desire to have MORE (in the dining hall)	
Take-away meals that are nutrient-dense and "filling"	5%
Seafood options including fish, shellfish, and sushi	8%
More "affordable" options	8%
Greater variety (e.g., more options of cultural cuisines)	13%
Prepared with locally grown and fresh-prepared food items	28%
Plant-based	38%
The kinds of foods students desire to have LESS (in the dining hall)	

Dessert items	11%
Animal products including meat and dairy	16%
Overly processed or poorly prepared foods (ie. pre-packaged, soggy or salty foods)	28%
Fast foods including fried food, high fat food and chain restaurants (ie. pizza, burgers)	45%

5.4 Discussion

Our study demonstrates that the theory of planned behavior framework extended with several additional constructs including psychosocial factors relating to food waste and food related activities can explain the food waste behaviors among young adults attending university. As expected by the Theory of Planned Behavior, the intention to reduce food waste was among the greatest predictors of self-reported food waste; and the intention to reduce food waste was influenced by perceived behavioral control and personal attitudes.[99] Perceived behavioral control not only influenced the intention to reduce food waste but was also found to have a direct, strong influence on the amount of self-reported food waste. This finding aligns with previous literature.[21-24] Individuals who felt they had the ability to control how much food they wasted reported less food waste.

Perceived behavioral control among students was strongly correlated to all food related activities including food planning, food shopping, leftover reuse activities and self-efficacy of food management. This finding suggests that providing students with the knowledge and skills to engage in food related activities to reduce their own food waste, may translate into less food wasted. A similar association was found among a sample of households in the UK, in which consumers who felt they could cook food in batches and properly store leftovers in the refrigerator or freezer also reported to having better food management skills and reportedly threw away less food.[23] Food planning activities such as planning meals in advance and taking food inventory before grocery shopping; and

food shopping activities such as avoiding purchasing in bulk or making impulse purchases have also previously been associated with less food waste.[21,22] Traditionally, young adults have been suggested to having poor food management skills, and thus throwing away greater quantities of food.[11] Previous studies have also identified young adults attending university to have limited skills to prepare food from raw and fresh ingredients.[11] Additionally, students have reported not knowing how much to purchase when grocery shopping, often over purchasing food, and frequently forgetting food in the refrigerator, allowing it to spoil. [11] It has been suggested to educate students on food waste prevention strategies such as how to plan meals and create grocery shopping lists, how to appropriately store food and read food date labels, and how to cook for one person. [11]

Further aligning with previous findings,[23,24] perceived health risk of consuming leftover foods and the good provider identity were found to be barriers to reducing one's food waste. Providing students with the knowledge of proper food safety and food hygiene may help to overcome these barriers. Additionally, it has been suggested that making students aware of the financial, environmental and social burden of food waste may motivate students to overcome these barriers.[7-8,11,102] In this study, we found that having financial and personal concerns relating to food waste positively influenced student's intention to reduce how much food they thrown away. Previous studies have also observed this finding.[23,24] Environmental concerns were not significantly associated with the intention to reduce food waste or with self-reported food waste quantities, however this conflicts with a recent finding from a convenience sample of university students who reported environmental sustainability was very important to them.[10]

In this study, environmental concerns relating to food waste were strongly correlated to personal norms, which in turn were strongly associated with a higher intention to reduce food waste. This suggests that personal norms may be a mediator between having environmental concerns relating to food waste and having the intention to reduce food waste.

Different from findings in previous literature,[24] age was associated with having less motivation to reduce food waste. This may be explained because our sample included young adults age 18 – 35 years. Older students within this range may have children, feel the need to be a good provider to their children, spend more on grocery shopping and stock up of food in case of emergency – all factors that have been related to less intention to reduce food waste and higher quantities of food waste.[20,22-24,]

We further asked students to identify reasons for wasting food while on and off campus. Reasons for wasting food both on and off campus were very different. On campus, not liking the taste or quality of the food served were contributing barriers to reducing food waste. These findings align with a study conducted at Berkeley university where taste expectations greatly influenced how much food students threw away.[39] In fact, students have previously reported to commonly taking more food than they could consume in the university dining hall as a safeguard in case they did not like something that was served.[11] Not having proper food storage facilities on campus was further identified as a barrier. Off campus students indicated food management activities as the biggest barriers to reducing their food waste. This supports a recent finding that waste reduction efforts targeting young adults attending university should be different for students living on campus and off campus.[95] It has been previously suggested that food

waste reduction initiatives should be different whether targeting students living on campus or off campus. Suggested strategies on campus have included involving students in menu planning, recipe development and taste testing of new foods to help increase acceptability and likability of the food served,[12] and providing facilities where students may store leftovers or packed meals while on campus.[21] Waste reduction efforts targeting students living off campus should focus on providing the skills and education for food management such as planning, shopping, preparing and storing food. Additionally, educating students on the consequences of food waste by providing signage of statistics on hunger, financial burden, and environmental degradation may impact all students.[7,11]

Further, we asked students to indicate which food waste reduction strategies they felt would be the most feasible and best received by their peers. Students felt strongly about creating a sharing system where leftover food could be shared or donated among peers. This strategy has also been suggested in previous literature conducted among a group of young adults.[11] Previous efforts to create a sharing system among consumers have shown promise in this concept.[103] In fact, organizations such as the Food Recovery Network (FRN), and a mobile application, Too Good To Go,[103] have already been at work to recover surplus foods to connect to consumers in the nearby communities. Universities may be able to learn from this design to create their own food sharing systems on campus.

5.4.1 Limitations and Implications for Future Research

This study has several limitations. The data was collected at a large university in Maryland and may not generalize to all U.S students. Further, students voluntarily opted to participate, and thus our sample may be representative of the true

student body. Bias may have been introduced by social desirability and by the accuracy of student's ability to recall how much food they throw away.

This is however the first study to test food waste behaviors among university students using a behavioral model, such as the theory of planned behavior, and thus provides meaningful insight into where to focus food waste reduction strategies in this setting. Although the model proved a good fit to explain food waste behaviors among this population, a common criticism of the TPB framework is the ability to translate the intention of the behavior into behavioral action. In other words, how do we move someone from having the intention to reduce food waste, to reducing their food waste. The food waste reduction strategies suggested in this study were based on the drivers identified as significant to both the intention to reduce food waste as well as self-reported food waste. Future studies should investigate the effectiveness of such strategies on reducing the amount of food wasted. Additionally, a new phenomenon of food insecurity among students is being observed, with a prevalence of every 1 in 5 students experiencing food insecurity.[57] Future studies also should investigate the feasibility and effectiveness of food waste reduction strategies that synergistically reduce waste while also making more nutritious food accessible and available to students.

Chapter 6: Discussion

6.1 Summary of Findings from the Exploratory Research

The problem of food waste is significant and increasingly recognized as a top priority on national agendas. In 2015, the EPA and the USDA called for a 50% reduction in food waste by 2030.[83] Indeed, collaboration by all organizations across the food supply chain, including academic institutions, is needed to achieve to this goal. To date, over 170 college and universities have joined as participants in the U.S. Food Waste Challenge.[83] Despite this commitment, there remains little understanding of the magnitude of the food waste problem in this setting and of the opportunities that may be effective in reducing food waste among students in this setting. The current project aimed to investigate the food waste environment in the university setting, and gain insight into the personal, behavioral, and environmental drivers that may influence food waste behaviors among students.

In the present study, student plate waste was found to range from 5% to 14% of all food served in the university dining hall facility, an estimate that is comparatively higher than estimates from previous literature.[24,65] This may be because our study was conducted at an all-you-can-eat dining hall establishment, and there is concern that waste in these facilities is higher because there is an expanded selection of menu options that have to be prepared in larger quantities to last throughout the day.[3,92] However, the all-you-can-eat dining hall facility has also been a strategy to increase the availability and accessibility of food to students who experience food insecurity. Creative solutions are needed to target sustainable strategies that may help reduce food waste while also addressing food insecurity. Strategies such as pre-portioning side items, reducing the

number of options on the menu, and eliminating trays from the dining hall may help to prevent over selection of food. In fact, in this study, we found that students perceived providing appropriate portion sizes as one of the most effective strategies to reduce food waste. We also identified foods that are frequently thrown away by students in the dining hall facility, including items such as pizza, rice, and noodles dishes, fruits and vegetables and whole grains. Focusing portion control initiatives on these food items may have a better impact on food waste reduction.

Catering food selection to meet students taste expectations may also be effective in reducing food waste in the university dining hall facility. Personal taste preference has been suggested to greatly influence how much food students waste.[39] Similarly, in the current study, students reported taste and quality expectations of the food served to be the top reason why they throw away food on campus. Involving students in menu planning and recipe development may be effective in improving likability of the food served.[12] Additionally, holding taste tests of new recipes may help increase acceptability of new or unfamiliar menu items.[12] Serving foods that students report wanting to see more of in the dining hall may also influence how much they throw away. We found that students want to see more plant-based meal options, and freshly prepared meals using foods from local vendors. Advertising foods that were produced from local vendors at the point of purchase may also be a strategy to help increase the acceptability of menu items. Additionally, providing training for food service workers on standardized recipe preparation techniques may help overall taste, quality, and consistency of the menu item.

Findings from the behavioral survey revealed that self-reported food waste was strongly influenced by the intention to reduce food waste and perceived behavioral

control. In turn, the intention to reduce food waste was strongly influenced by having the confidence for food management, feeling guilty about throwing food away, and having financial concerns related to food waste. Increasing awareness of the financial, environmental, and social consequences of food waste may be effective in raising student's intention to reduce their waste. Launching a campus-wide waste reduction campaign that provides shocking images of the volume of food that students waste including statistics of monetary value, environmental degradation and hunger may motivate students to reduce their food waste.[7] Additionally, providing students with the skills to properly manage their food may help to prevent how much food they throw away.

In this study, we found that food planning, food shopping and leftover reuse activities were all strongly associated with the perceived behavioral control to reduce food waste. Having the knowledge and skills to plans meals in advance, purchase foods in a way that all purchased food is consumed, and create meals out of leftovers or raw, fresh ingredients has been associated with less reported food waste.[11] Providing these skills for students through required coursework, such as "Food Management 101," may be effective in helping them to properly manage their food related activities to avoid food waste.

Further, almost 50% of students reported food recovery to be the most perceived feasible and effective solution to reduce food waste in this setting. The Food Recovery Network (FRN) is a campus run group that works to recover surplus food from dining hall facilities and package it to send to emergency food resources in the nearby community, such as soup kitchens, food banks, safe houses, etc.[81] Since the start of FRN

in 2011, it is estimated that 3,210,648 meals have been recovered. [81] The organization has evolved from food recovery to food donation to creating a sharing system where community members sit down and have a meal together. Implementing this type of sharing system on campus, may be effective in not only reducing food waste, but also may create opportunity to provide more nutritious and abundant food to students on campus. Creating food sharing systems in this setting may not only help reduce food waste but also address a growing need of food security among students, as food insecurity has become more increasingly prevalent on college campuses.

6.2 Limitations

This formative research had several limitations. The data was collected at a large university in Maryland and may not generalize to all U.S. universities and students. Plate waste volumes were measured in the university dining hall facility where data collections activities were visible to students and may have introduced some bias. Students may have changed their food waste behaviors due to recognizing their food scraps being collected and weighed. Additionally, students voluntarily opted into the behavioral survey, which may have introduced sampling bias. Most respondents were female and white, and this may not represent the entire student body. Additionally, food related behaviors were measured against self-reported food waste quantities. As these quantities were recalled, recall bias may have been introduced.

Additional limitations exist related to interpretation of our data. The greenhouse gas emission adapted in this study were related to the production of the food and does not consider the methane gas that is released as food decomposes in a landfill, so our GHGE

estimate is likely underestimated. Additionally, the 161 SR-28 food codes used to represent food served in the dining hall facility generally corresponded to basic ingredients but were used to represent all varieties of food served in the dining hall facility. Further, although our estimates indicate significant potential to reduce emission of harmful greenhouse gases and make more nutrients available to consumers, we do not know how these nutrients translate into specific foods and/or meals.

However, this research also has many strengths. To the best of our knowledge, this is the first study to use university dining hall facilities to systematically describe the composition of food served in a university dining hall facility and compare this to the volume of plate waste generated by students. Additionally, the methods adapted to contextualize the nutritional value and greenhouse gas emissions of student plate waste were validated in previous literature. This is also the first study to date to investigate food waste related behaviors among students using a behavioral model, such as the Theory of Planned Behavior to quantitatively investigate associations between key variables of interest to identify the drivers of food waste behaviors among students.

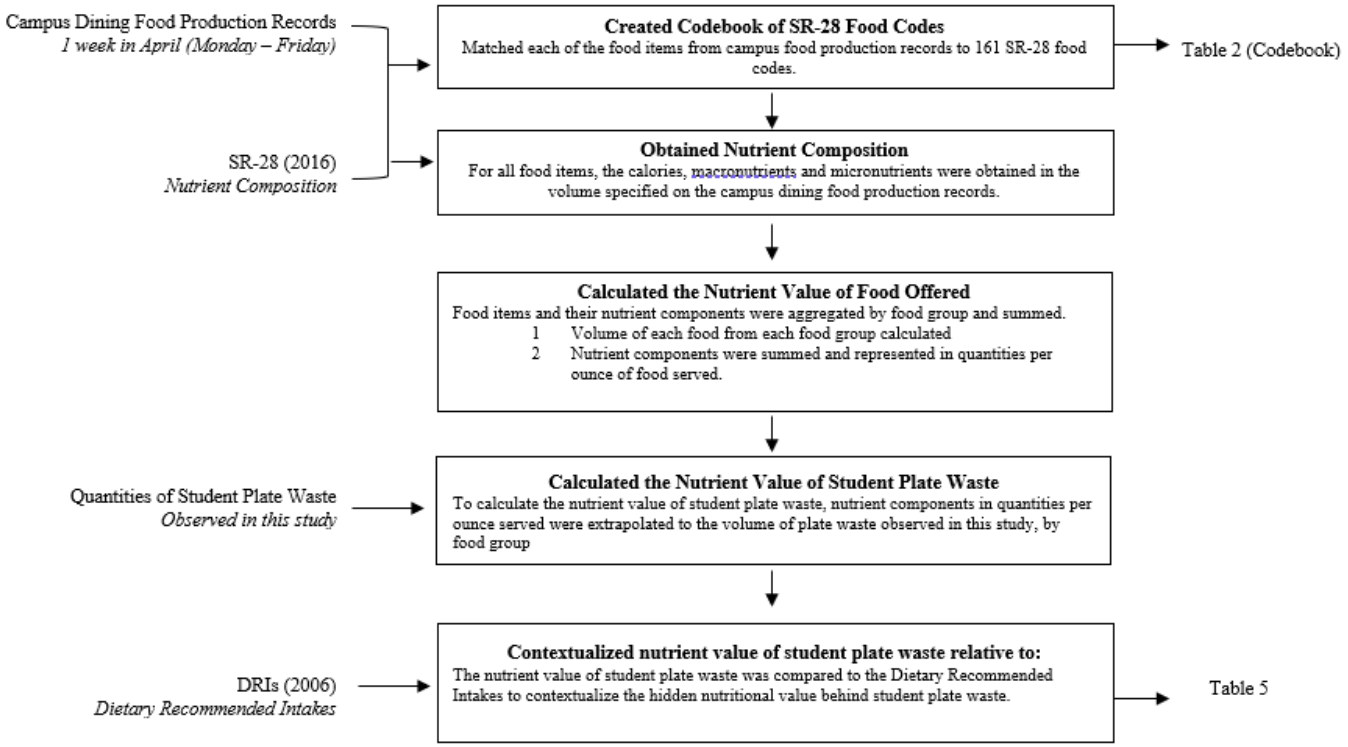
6.3 Conclusion

Our findings indicate that food waste in college/universities is a significant problem with enormous potential for food waste reduction. To the best of our knowledge, this is the first study to investigate the food waste environment comprehensively and systematically in the university setting. Our study addressed significant knowledge gaps and with our findings, we were able to provide recommendations for opportunity within the food environment in this setting for food waste reduction. Future research in this

setting should focus on the effectiveness of food waste reduction strategies in reducing food waste among students. Future research should also investigate the feasibility of a food sharing system within the campus community, where surplus foods are recovered and made available to students at a very low or no cost. It would be interesting to investigate the healthfulness of such meals and how this type of program might be received by students.

Appendices

Appendix 1. Figure 3. Data Sources and Methods Used to Calculate The Nutritional Value of Plate Waste in the Dining Hall Facility



Appendix 2. Table 2. Food Codebook

Food items listed on the campus food production records were matched to 161 SR-28 food codes identified in the National Nutrient Database for Standard Reference, Release-28. Descriptions of the 161 SR-28 food codes used in this study are provided in the table below.

Detailed information on the application of the food codes used from this database, their analysis and the results found are included in Chapter 4, (Paper 1).

SR-28 Code	USDA National Nutrition Database (SR-28) Food Description	Food Subcategory
06068	Soup, vegetarian, vegetable, canned, condensed	Fruits & Vegetables
06159	Soup, tomato, canned, condensed	Fruits & Vegetables
06168	Sauce, ready-to-serve, pepper or hot	Fruits & Vegetables
06626	Sauce, pesto, ready-to-serve, refrigerated	Fruits & Vegetables
06700	Soup, vegetable broth, ready to serve	Fruits & Vegetables
06931	Sauce, pasta, spaghetti/marinara, ready-to-serve	Fruits & Vegetables
09038	Avocados, raw, California	Fruits & Vegetables
09050	Blueberries, raw	Fruits & Vegetables
09184	Melon, honeydew, raw	Fruits & Vegetables
09219	Tangerines, (mandarin oranges), canned, juice pack	Fruits & Vegetables
09316	Strawberries, raw	Fruits & Vegetables
11742	Broccoli, cooked, boiled, drained with salt	Fruits & Vegetables
11109	Cabbage, raw	Fruits & Vegetables
11124	Carrots, raw	Fruits & Vegetables
11205	Cucumber with peel, raw	Fruits & Vegetables
11243	Mushrooms, portabella, grilled	Fruits & Vegetables
11253	Lettuce, green leaf, raw	Fruits & Vegetables
11282	Onions, raw	Fruits & Vegetables
11286	Onions, yellow, sautéed	Fruits & Vegetables
11333	Peppers, sweet, green, raw	Fruits & Vegetables
11457	Spinach, raw	Fruits &Vegetables
11510	Sweet potato cooked boiled without skin	Fruits & Vegetables
11514	Sweet potato, canned, mashed	Fruits & Vegetables
11529	Tomatoes, red, ripe, raw, year-round average	Fruits & Vegetables
11530	Tomatoes, red, ripe, cooked	Fruits & Vegetables
11603	Yam bean (jicama), raw	Fruits & Vegetables
11649	Tomato products, canned, sauce, Spanish style	Fruits & Vegetables

11660	Tomatoes, red, ripe, cooked, stewed	Fruits & Vegetables
11693	Tomatoes, crushed, canned	Fruits & Vegetables
11702	Artichokes, cooked, boiled, drained with salt	Fruits & Vegetables
11723	Beans, snap, green, cooked, boiled, drained, with salt	Fruits & Vegetables
11745	Brussel sprouts, cooked, boiled, drained with salt	Fruits & Vegetables
11757	Carrots, cooked, boiled, drained, with salt	Fruits & Vegetables
11761	cauliflower, cooked, boiled, drained, with salt	Fruits & Vegetables
11764	celery, cooked, boiled, drained with salt	Fruits & Vegetables
11768	Collards, cooked, boiled, drained with salt	Fruits & Vegetables
11790	Kale, cooked, boiled, drained, with salt	Fruits & Vegetables
11797	Mushrooms, white, cooked, boiled, drained with salt	Fruits & Vegetables
11854	Spinach, cooked, boiled, drained with salt	Fruits & Vegetables
11860	Squash, summer, scallop, cooked, boiled, drained, with salt	Fruits & Vegetables
11861	Squash, summer, zucchini, includes skin, cooked, boiled, drained with salt	Fruits & Vegetables
11866	Squash, winter, butternut, cooked, baked with salt	Fruits & Vegetables
11955	Tomatoes, sun-dried	Fruits & Vegetables
11980	Peppers, chili, green, canned	Fruits & Vegetables
11209	Eggplant, raw	Fruits & Vegetables
11260	Mushrooms, white, raw	Fruits & Vegetables
43312	Vegetables, mixed (corn, lima beans, peas, green beans, carrots) canned, no salt	Fruits & Vegetables
06112	Teriyaki sauce, ready to serve	Starch & Added Sugar
06116	Gravy, beef, canned, ready-to-serve	Starch & Added Sugar
06120	Gravy, chicken, dry	Starch & Added Sugar
06624	SMART SOUP, Thai Coconut Curry	Starch & Added Sugar
06972	Sauce, tomato, chili sauce, bottled with salt	Starch & Added Sugar
09008	Apples, canned, sweetened, sliced, drained, heated	Starch & Added Sugar
09239	Peaches, canned, extra light syrup solids and liquids	Starch & Added Sugar
09256	Pears, canned, light syrup pack, solids and liquids	Starch & Added Sugar
11828	Potatoes, baked, flesh and skin, with salt	Starch & Added Sugar
11296	Onion rings, breaded, par fried, frozen, prepared, heated in oven	Starch & Added Sugar
11412	Potatoes, French fried, steak fries, salt added in processing, frozen, oven-heated	Starch & Added Sugar
11632	Peppers, jalapeno, canned, solids and liquids	Starch & Added Sugar
11672	Potato Pancakes	Starch & Added Sugar
11770	Corn, sweet, yellow, cooked, boiled, drained with salt	Starch & Added Sugar
11934	Potatoes, mashed, home-prepared, whole milk and butter added	Starch & Added Sugar
16124	Soy sauce made from soy (tamari)	Starch & Added Sugar
18009	Biscuits, plain or buttermilk, frozen, baked	Starch & Added Sugar
18029	Bread, French or Vienna	Starch & Added Sugar
18030	Bread, French or Vienna, toasted (includes sourdough)	Starch & Added Sugar
18033	Bread Italian	Starch & Added Sugar
18036	Bread, multi-grain, toasted (includes whole grain)	Starch & Added Sugar
18044	Bread, pumpernickel	Starch & Added Sugar
18060	Bread, rye	Starch & Added Sugar

18069	Bread, white, commercially prepared	Starch & Added Sugar
18085	Bread, stuffing, cornbread, dry mix, prepared	Starch & Added Sugar
18279	Muffins, corn, commercially prepared	Starch & Added Sugar
18349	Rolls, French	Starch & Added Sugar
18353	Rolls, hard (includes Kaiser)	Starch & Added Sugar
18621	Nabisco, Nabisco Ritz Crackers	Starch & Added Sugar
18946	Pie crust, refrigerated, regular, baked	Starch & Added Sugar
18967	Bread, white wheat	Starch & Added Sugar
18970	Tortillas, ready-to bake or fry, flour, shelf stable	Starch & Added Sugar
18971	Bread, potato	Starch & Added Sugar
19296	Honey	Starch & Added Sugar
20019	Corn flour, masa, unenriched, white	Starch & Added Sugar
20029	couscous, cooked	Starch & Added Sugar
20045	Rice, white, long-grain, regular, enriched, cooked	Starch & Added Sugar
20113	Noodles, Chinese, chow-mien	Starch & Added Sugar
20115	Japanese Soba noodles, cooked	Starch & Added Sugar
20134	Rice noodles, cooked	Starch & Added Sugar
20521	Pasta, cooked, unenriched, with added salt	Starch & Added Sugar
21138	Fast foods, potato, French fried in vegetable oil	Starch & Added Sugar
22899	Ravioli, cheese-filled, canned	Starch & Added Sugar
22901	Tortellini, pasta with cheese filling, fresh-refrigerated, as purchased	Starch & Added Sugar
22901	Tortellini, pasta with cheese filling, fresh refrigerated, as purchased	Starch & Added Sugar
27063	Sauce, enchilada, red, mild, ready to serve	Starch & Added Sugar
32024	Rice mix cheese flavor dry mix unprepared	Starch & Added Sugar
35234	Piki bread, made from blue cornmeal (Hopi)	Starch & Added Sugar
43015	Salad dressing, Caesar dressing, regular	Starch & Added Sugar
01032	Cheese, parmesan, grated	Dairy
01025	Cheese, Monterey	Dairy
01028	Cheese, mozzarella, part skim	Dairy
01030	Cheese, muenster	Dairy
01035	Cheese, provolone	Dairy
01036	Cheese, ricotta, whole milk	Dairy
01040	Cheese, swiss	Dairy
01042	Cheese, pasteurized process, American, fortified with vitamin D	Dairy
01286	Yogurt, Greek, vanilla, nonfat	Dairy
01270	Cheese, cheddar, sharp, sliced	Dairy
06053	Soup, cream of potato, canned, condensed	Dairy
06584	Soup, broccoli cheese, canned, condensed, commercial	Dairy
06930	Sauce, cheese, ready to serve	Dairy
12095	Nuts, chestnuts, Chinese, boiled and steamed	Plant-Based Protein
16005	Beans, baked, home prepared	Plant-Based Protein
16033	Beans, kidney, red, mature seeds, cooked, boiled, with salt	Plant-Based Protein
16051	Beans, white, mature seeds, canned	Plant-Based Protein
16059	Chili with beans, canned	Plant-Based Protein
16122	Soy Protein Isolate	Plant-Based Protein

16158	Hummus, commercial	Plant-Based Protein
16162	MORI-NU Tofu, silken, firm	Plant-Based Protein
16317	Beans, Black turtle, mature seeds, cooked, boiled, with salt	Plant-Based Protein
16350	Beans, white, mature seeds, cooked boiled, with salt	Plant-Based Protein
16370	Lentils, mature seeds, cooked, boiled, with salt	Plant-Based Protein
05012	Chicken, broiler or fryers, meat only, cooked, fried	Animal Protein & Fish
05126	Chicken, stewing, meat only, cooked, stewed	Animal Protein & Fish
05220	Turkey, whole, breast, meat only, cooked, roasted	Animal Protein & Fish
05333	Chicken, ground, crumbles cooked, pan-browned	Animal Protein & Fish
05342	Chicken broilers or fryers, rotisserie, original seasoning, breast, meat only, cooked	Animal Protein & Fish
05675	Chicken, skin (drumstick and thighs), cooked, roasted	Animal Protein & Fish
05747	Chicken, broiler or fryers, breast, skinless, boneless, meat only, cooked, grilled	Animal Protein & Fish
06015	Soup, canned, chunky, ready-to-serve	Animal Protein & Fish
06026	Soup, chili beef, canned, condensed	Animal Protein & Fish
06028	Soup, clam chowder, Manhattan, canned	Animal Protein & Fish
06030	Soup, clam chowder, new England, canned, condensed	Animal Protein & Fish
07008	Bologna, beef and pork	Animal Protein & Fish
07046	Turkey breast, low salt, prepackaged or deli, luncheon meat	Animal Protein & Fish
07057	Pepperoni, beef and pork, sliced	Animal Protein & Fish
07914	Sausage Italian, sweet links	Animal Protein & Fish
07938	Ham, honey, smoked, cooked	Animal Protein & Fish
07944	Turkey, white, rotisserie, deli cut	Animal Protein & Fish
07945	Frankfurter, beef, heated	Animal Protein & Fish
10065	Pork, fresh, loin, top loin (roasts), boneless, separable lean and fat, cooked, roasted	Animal Protein & Fish
10860	Pork, cured, bacon, cooked, baked	Animal Protein & Fish
10864	Pork, bacon, rendered fat, cooked	Animal Protein & Fish
10998	Canadian bacon, cooked, pan fried	Animal Protein & Fish
13342	Beef, sandwich steaks, flaked, chopped, formed and thinly sliced, raw	Animal Protein & Fish
13347	Beef, cured, corned beef, brisket, cooked	Animal Protein & Fish
13439	Beef, loin, tenderloin steak, boneless, separable lean and fat, trimmed to 0" fat, all grades, cooked, grilled	Animal Protein & Fish
15016	Fish, cod, Atlantic, cooked, dry heat	Animal Protein & Fish
15019	Fish, cod pacific, raw (may have been previously frozen)	Animal Protein & Fish
15151	Crustaceans, shrimp, mixed species, cooked, moist heat	Animal Protein & Fish
15209	Fish, salmon, Atlantic, wild, cooked, dry heat	Animal Protein & Fish
15233	Fish, catfish, channel, wild, cooked, dry heat	Animal Protein & Fish
22978	Chicken tenders breaded frozen, prepared	Animal Protein & Fish
23220	Beef, ground, unspecified fat content, cooked	Animal Protein & Fish
43366	Turkey, wing, smoked, cooked, with skin, bone removed	Animal Protein & Fish
18064	Bread, Wheat	Whole Grains
18075	Bread, whole-wheat, commercially prepared	Whole Grains

20006	Barley, pearled, cooked	Whole Grains
20037	Rice, brown, long-grain, cooked	Whole Grains
20076	Wheat, durum	Whole Grains
20125	Pasta, whole wheat, cooked	Whole Grains
20137	Quinoa, cooked	Whole Grains
28295	Tortillas, ready-to-bake or fry, whole wheat	Whole Grains

Appendix 3. Table 3 (Adapted from Table S1) Food Availability & Losses and estimated greenhouse gas emissions

The greenhouse gas emission estimates of the food items listed in this table are the result of a meta-analysis of studies using a life-cycle approach to estimate the greenhouse gas emissions of various food items. The original table is available as Table S1 in a study published by Heller & Keoleian, 2014.

The food items listed in this table were aggregated by the respective food subcategory used in this study, and an average of the greenhouse gas emissions per food subcategory was calculated to be used in further investigation. Detailed information on the application of this table, the analysis completed, and results found are included in Chapter 4 (Paper4).

Food Subcategory	Food Item	Avg. Greenhouse Gas Emissions (CO2 eq/kg food)
1	Rice	1.14
1	Corn Products	0.66
1	sweet corn	0.73
1	potatoes	0.21
1	added sugars and sweeteners	0.96
1	other added fats & oils	6.3
2	Citrus	0.5
2	Apples	0.36
2	Apricots	0.36
2	Avocados	1.27
2	Bananas	1.32
2	Blueberries	0.33
2	Cantaloupe	0.27
2	Cherries	0.36
2	Cranberries	0.33
2	Grapes	0.29
2	Honeydew	0.27
2	Kiwi	0.6
2	Mangoes	0.97

2	Papaya	0.97
2	Peaches	0.36
2	Pears	0.29
2	Pineapples	0.31
2	plums	0.36
2	raspberries	0.33
2	strawberries	0.35
2	watermelon	0.27
2	canned fruit	1.05
2	frozen fruit	1.03
2	dried fruit	1.03
2	fruit juices	1.03
2	artichokes	0.73
2	asparagus	8.87
2	bell peppers	0.88
2	broccoli	0.4
2	Brussel sprouts	0.33
2	cabbage	0.12
2	carrots	0.53
2	cauliflower	0.39
2	celery	0.73
2	collards	0.33
2	cucumbers	0.66
2	eggplant	1.3
2	escarole & endive	1.46
2	garlic	0.33
2	kale	0.33
2	head lettuce	1.08
2	romaine &leaf lettuce	1.08
2	mushrooms	0.73
2	mustard greens	0.33
2	okra	0.73
2	onions	0.39
2	pumpkin	0.09
2	radishes	0.33
2	snap beans	0.73
2	spinach	0.13
2	squash	0.09
2	sweet potatoes	0.33
2	tomatoes	0.67
2	turnip greens	0.33
2	canned vegetables	1.1
2	Frozen vegetables	1.44
2	Processed & dehydrated vegetables	1.3
2	salad and cooking oils	1.63
3	Fluid Milk	1.34

3	yogurt	2.02
3	total cheese	9.78
3	cottage cheese	1.8
3	ice cream and ice milk	3.1
3	Other frozen dairy	3.1
3	Evap. Condensed milk	3.2
3	dry milk products	10.4
3	Half-n-half (dairy and fat content)	3.77
3	eggnog (dairy and fat content)	3.77
3	light & heavy cream	3.77
3	sour cream	2.6
3	cream cheese	1.92
3	butter	11.92
3	margarine	1.36
4	meat	20.15
4	beef	26.45
4	veal	7.8
4	lamb	6.87
4	pork	22.9
4	poultry	5.05
4	fresh & frozen fish	3.83
4	fresh & frozen shellfish	11.74
4	canned fish & shellfish	4.11
4	cured fish	4.11
4	eggs	3.54
4	lard & beef tallow	11.92
4	shortening	2.4
5	lima beans	0.73
5	Legumes	0.78
5	peanuts	1.94
5	total tree nuts	1.17
6	Total Wheat Flours	0.58
6	Rye Flour	0.36
6	Barley Products	0.6
6	Oat Products	0.47

Appendix 4. Table 7 The Psychosocial Drivers and Food Related Activities Influencing Food Waste Behaviors Among Students

	M	SD
Quantities of Food Waste (self-reported), Cronbach's-α = 0.77		
Starch and Added Sugars	1.99	1.011
Fruits and Vegetables	2.07	1.019
Dairy Products	1.8	0.976
Animal Proteins and Seafood	1.83	1.074
Plant-Based Proteins	1.6	0.863
Whole Grains	1.74	0.923
Intention to reduce food waste, Cronbach's-α = 0.853		
I try not to waste food at all	4.38	0.816
I always try to eat all purchased foods	4.46	0.761
I try to throw away only very little amounts of food	4.43	0.79
I try to use all my food leftovers	4.34	0.874
Personal Attitudes, Cronbach's-α = 0.705		
It is unnecessary to waste food; it can always be used in some way	3.98	1.02
It is immoral to discard foods while others in the world are starving	3.61	1.15
Financial Attitudes, Cronbach's-α = 0.641		
I think that wasting food is a waste of money	4.59	0.71
I cannot afford to pay for foods that are then discarded	3.31	1.159
Saving money does not motivate me to discard less food **R*	3.71	1.098
I rarely think about money when I throw away food **R*	3.81	1.156
Perceived Health Risk, Cronbach's-α = 0.612		
I believe that the risk of becoming ill as a result of eating food past its use-by date is high	2.99	1.19
I am worried that eating leftovers may damage my health **R*	2.48	1.359
I think consuming leftovers is harmless **R*	1.82	0.927
I think that one can safely eat food products when the use-by date expired a few days ago **R*	2.35	1.055
Environmental Attitudes, Cronbach's-α = 0.757		
I worry about the greenhouse gases, energy, and water resources that it took to get food to my plate	3.64	1.224
I believe that leaving uneaten food on my plate has a negative effect on the environment	3.82	1.037
I feel that one person's food waste can have a negative effect on the environment	3.82	0.98
Good Provider Identity, Cronbach's-α = 0.628		
I regularly buy many fresh products although I know that not all of them will be eaten	2.6	1.178
I like to provide a large variety of foods at shared mealtimes so that everyone can have something they like	3.35	1.061
I always have fresh products available to be prepared for unexpected guests or events (ie. illness)	2.62	1.157
When I am expecting guests, I like to buy more food than is necessary because I am a generous host	3.35	1.156
Personal Norms, Cronbach's-α = 0.724		
I feel bad when I throw away food	4.39	0.871

It is contrary to my beliefs and values when I have to discard food	3.81	1.084
Food Shopping Activities, Cronbach's-α = 0.66		
I often buy unintended food products when shopping	2.92	1.311
I often buy food in packages that are bigger than what I need	2.92	1.252
Leftover Reuse Activities, Cronbach's-α = 0.534		
I eat my leftovers as is, or just reheat when I am ready	4.34	0.724
I transform my leftovers into a different dish by adding some ingredients before eating them *D**	2.93	1.258
I store my leftovers correctly so they will last until I am ready to eat them again	4.18	0.778
Food Planning Routines, Cronbach's-α = 0.514		
Before I go grocery shopping, I check my food inventory and make a list of what I need	4.13	0.995
I plan my meals a few days in advance and I keep this plan	3.07	1.245
Perceived Behavioral Control to Reduce Food Waste, Cronbach's-α = 0.711		
I find it difficult to prepare a new meal from leftovers **R*	3.25	1.236
I find it difficult to make sure that I throw away only small amounts of food **R*	3.54	1.101
I find it difficult to purchase foods in such a way that all food I purchase is eaten **R*	3.24	1.237
I have the feeling that I cannot do anything about the food that I throw away **R*	3.51	1.222
Other roommates make it impossible for me to reduce the amount of food that I throw away in my household **R*	3.58	1.2
The anytime dining system in the dining hall makes it impossible for me to reduce the amount of food that I throw away **R*	3.43	1.136
Self-Efficacy of Food Management Skills, Cronbach's-α = 0.791		
I have the knowledge and skills to reduce the amount of food that I throw away	3.96	1.001
I can plan my meals and use the food in my refrigerator and pantries before buying new food items	3.99	0.962
I have the skills needed to cook and prepare meals from raw and fresh ingredients	4	1.129
I can store food at the appropriate temperature for the right amount of time	4	0.995
I can interpret food label dates (best-by, sell-by and use-by dates)	3.95	1.05
I can finish all my food when I eat on or off campus	3.85	1.032

All items were rated using a 5-point likert scale ("strongly disagree" = 1 to "strongly agree" = 5). Higher scores corresponded to a higher agreement with each statement.
D – item deleted if better reliability achieved when excluded.*
**R – items that were reverse coded*

Appendix 5. Table 8. Awareness of the Food Waste Problem and Knowledge of Use-By Dates and Proper Food Storage

	% Correct (N = 338)
Knowledge of Use-by dates (M =2.06, SD = ±.0.582)	
The "use-by" date means that food products can become a health risk if they are used after that date, and should therefore no longer be consumed	27%
Many retailers put the "Sell-by" date on easily perishable products so that they can discard them in time	63%
The "best-before" date indicates how long a product will retain its specific food characteristics when stored properly. Products can still be consumed after this date	86%
Knowledge of Proper Food Storage (M=2.36 SD = ±0.578)	
Fruits excrete gas during storage, which keeps vegetables fresh longer. Fruits and vegetables should therefore be stored together	40%
Raw potatoes should not be stored in the refrigerator.	50%
Leftovers from warm meals should be cooled down before they are put in the refrigerator or freezer	63%
Items worded as "Choose whether you agree or disagree with the following statements." items were changed into a dichotomous response of 0 (incorrect) and 1 (correct). *Students were asked to agree or disagree with each item. Correct agreement was assigned a score of 1, and summed scores ranged from 0 to 3 for each scale. Higher summed scores indicated greater knowledge.*	

	% Aware (N =338)
Awareness of the Food Waste Problem (Cronbach's-α = 0.66), (M =3.35 SD = ± 1.403)	
Issues of food that is thrown out or otherwise eaten by human?	76%
Ways to reduce the amount of food you throw away?	67%
About food expiration dates?	56%
About composting?	82%
Program or initiatives to reduce how much food is thrown away ON CAMPUS	47%
Items worded as "In the past year, have you seen or heard anything in the news, social media or elsewhere about..." *items were changed into a dichotomous response of 1 (Yes) and 0 (No).* *A score of 1 was assigned to each response of yes, and summed scores ranged from 0 to 5. Higher summed scores indicated a higher awareness of the general food waste problem.*	

Bibliography

1. Barioni LG, Benton TG, Herrero M, et al; Intergovernmental Panel on Climate Change. Chapter 5: food security. https://www.ipcc.ch/site/assets/uploads/2019/08/2f.-Chapter-5_FINAL.pdf. Published July 8, 2019. Accessed August 8, 2019.
2. FAO, IFAD, UNICEF, WFP and WHO. The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. Rome, FAO. Licence: CC BY-NC-SA 3.0 IGO.2018.
3. Gunders D, Bloom J. *Wasted:* How America Is Losing up to 40 Percent of Its Food from Farm to Fork to Landfill. *New York: Natural Resources Defense Council;* 2017.
4. Rethink Food Waste. ReFed. ReFED: A Roadmap to Reduce U.S. Food Waste by 20 Percent. Further With Food. https://furtherwithfood.org/resources/refed-roadmap-reduce-u-s-food-waste-20-percent/. Published 2020. Accessed June 24, 2020.
5. Buzby JC, Farah-Wells H, Hyman J. The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States. *SSRN Electronic Journal*. 2014. doi:10.2139/ssrn.2501659
6. United States 2030 Food Loss and Waste Reduction Goal. EPA. https://www.epa.gov/sustainable-management-food/united-states-2030-food-loss-and-waste-reduction-goal. Published May 19, 2020. Accessed July 28, 2020.
7. Whitehair KJ, Shanklin CW, Brannon LA. Written Messages Improve Edible Food Waste Behaviors in a University Dining Facility. *Journal of the Academy of Nutrition and Dietetics*. 2013;113(1):63-69. doi:10.1016/j.jand.2012.09.015
8. Painter K, Thondhlana G, Kua HW. Food waste generation and potential interventions at Rhodes University, South Africa. *Waste Management*. 2016;56:491-497. doi:10.1016/j.wasman.2016.07.013
9. Pinto RS, Pinto RMDS, Melo FFS, Campos SS, Cordovil CM-D-S. A simple awareness campaign to promote food waste reduction in a University canteen. *Waste Management*. 2018;76:28-38. doi:10.1016/j.wasman.2018.02.044
10. Luecke L. Haste to no waste: a multicomponent food waste study in a university dining hall facility. Antonian Scholars Honors Program, St Catherine University. 2015;Paper 33. http://sophia.stkate.edt/shas_honors/33
11. Nikolaus CJ, Nickols-Richardson SM, Ellison B. Wasted food: A qualitative study of U.S. young adults perceptions, beliefs and behaviors. *Appetite*. 2018;130:70-78. doi:10.1016/j.appet.2018.07.026
12. Ellison B, Savchenko O, Nikolaus CJ, Duff BR. Every plate counts: Evaluation of a food waste reduction campaign in a university dining hall. *Resources, Conservation and Recycling*. 2019;144:276-284. doi:10.1016/j.resconrec.2019.01.046
13. Community Research Connections [CRC] Sustainable Community Development (n.d.). Definition of a sustainable food system. Retrieved From https://crcresearch.org/sites/default/files/u641/definition_of_a_sustainable_food_system.pdf.
14. Papargyropoulou E, Lozano R, Steinberger JK, Wright N, Ujang ZB. The food waste hierarchy as a framework for the management of food surplus and food waste. *Journal of Cleaner Production*. 2014;76:106-115. doi:10.1016/j.jclepro.2014.04.020

15. Gustafsson J, Cederberg C, Sonesson U, Emanuelsson A. The methodology of the FAO study: Global Food Losses and Food Waste-extent, causes and prevention"-FAO, 2011.
16. Lundqvist J, de Fraiture C, Molden D. Saving water: from field to fork: curbing losses and wastage in the food chain. Stockholm: Stockholm International Water Institute; 2008 May
17. Spiker ML, Hiza HA, Siddiqi SM, Neff RA. Wasted Food, Wasted Nutrients: Nutrient Loss from Wasted Food in the United States and Comparison to Gaps in Dietary Intake. *Journal of the Academy of Nutrition and Dietetics*. 2017;117(7). doi:10.1016/j.jand.2017.03.015
18. Hall KD, Guo J, Dore M, Chow CC. The Progressive Increase of Food Waste in America and Its Environmental Impact. *PLoS ONE*. 2009;4(11). doi:10.1371/journal.pone.0007940
19. Munesue Y, Masui T, Fushima T. The effects of reducing food losses and food waste on global food insecurity, natural resources, and greenhouse gas emissions. *Environmental Economics and Policy Studies*. 2014;17(1):43-77. doi:10.1007/s10018-014-0083-0
20. Quested T, Marsh E, Stunell D, Parry A. Spaghetti soup: The complex world of food waste behaviours. *Resources, Conservation and Recycling*. 2013;79:43-51. doi:10.1016/j.resconrec.2013.04.011
21. Stancu V, Haugaard P, Lähteenmäki L. Determinants of consumer food waste behaviour: Two routes to food waste. *Appetite*. 2016;96:7-17. doi:10.1016/j.appet.2015.08.025
22. Stefan V, Herpen EV, Tudoran AA, Lähteenmäki L. Avoiding food waste by Romanian consumers: The importance of planning and shopping routines. *Food Quality and Preference*. 2013;28(1):375-381. doi:10.1016/j.foodqual.2012.11.001
23. Graham-Rowe, Ella, Donna C. Jessop, and Paul Sparks. "Identifying motivations and barriers to minimising household food waste." *Resources, conservation and recycling* 84 (2014): 15-23.
24. Visschers VH, Wickli N, Siegrist M. Sorting out food waste behaviour: A survey on the motivators and barriers of self-reported amounts of food waste in households. *Journal of Environmental Psychology*. 2016;45:66-78. doi:10.1016/j.jenvp.2015.11.007
25. Quested T, Johnson H. Household food and drink waste in the UK: final report. Wastes & Resources Action Programme (WRAP). 2009 Nov.
26. Thyberg KL, Tonjes DJ, Gurevitch J. Quantification of Food Waste Disposal in the United States: A Meta-Analysis. *Environmental Science & Technology*. 2015;49(24):13946-13953. doi:10.1021/acs.est.5b03880
27. Silvennoinen K, Heikkilä L, Katajajuuri J-M, Reinikainen A. Food waste volume and origin: Case studies in the Finnish food service sector. *Waste Management*. 2015;46:140-145. doi:10.1016/j.wasman.2015.09.010
28. Heikkilä L, Reinikainen A, Katajajuuri J-M, Silvennoinen K, Hartikainen H. Elements affecting food waste in the food service sector. *Waste Management*. 2016;56:446-453. doi:10.1016/j.wasman.2016.06.019
29. Ofei KT, Werther M, Thomsen JD, Holst M, Rasmussen HH, Mikkelsen BE. Reducing Food Waste in Large-Scale Institutions and Hospitals: Insights From

Interviews With Danish Foodservice Professionals. *Journal of Foodservice Business Research*. 2015;18(5):502-519. doi:10.1080/15378020.2015.1093457
30. Eriksson M, Osowski CP, Malefors C, Björkman J, Eriksson E. Quantification of food waste in public catering services – A case study from a Swedish municipality. *Waste Management*. 2017;61:415-422. doi:10.1016/j.wasman.2017.01.035
31. Crisman, P. LOCAL FOOD AND FOOD WASTE, Runk Dining Hall Waste Audit. 2011. Retrieved From http://www.globalsustainability.virginia.edu/.
32. Merrow, K., Penzien, P., & Dubats, T. Exploring food waste reduction in campus dining halls. *Western Michigan University: Appropriate Technology and Sustainability The Campus as a Living Laboratory*.2012
33. Sodexo Dining Services at the University of Pittsburgh. Perch food waste audit report. Spring 2016. Retrieved From http://www.pc.pitt.edu/dining/documents/Perchaudit2016FINAL.pdf
34. Rajan J, Fredeen AL, Booth AL, Watson M. Measuring food waste and creating diversion opportunities at Canada's Green UniversityTM. *Journal of Hunger & Environmental Nutrition*. 2017;13(4):573-586. doi:10.1080/19320248.2017.1374900
35. Wilkie A, Graunke R, Cornejo C. Food Waste Auditing at Three Florida Schools. *Sustainability*. 2015;7(2):1370-1387. doi:10.3390/su7021370
36. Pearson D, Mirosa M, Andrews L, Kerr G. Reframing communications that encourage individuals to reduce food waste. *Communication Research and Practice*. 2016;3(2):137-154. doi:10.1080/22041451.2016.1209274
37. Thyberg KL, Tonjes DJ. Drivers of food waste and their implications for sustainable policy development. *Resources, Conservation and Recycling*. 2016;106:110-123. doi:10.1016/j.resconrec.2015.11.016
38. Parizeau K, Massow MV, Martin R. Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. *Waste Management*. 2015;35:207-217. doi:10.1016/j.wasman.2014.09.019
39. Lam Y. Why do UC Berkeley students waste food at dining halls. *University of California Berkeley.* 2010.
40. Heller MC, Keoleian GA. Greenhouse Gas Emission Estimates of U.S. Dietary Choices and Food Loss. *Journal of Industrial Ecology*. 2014;19(3):391-401. doi:10.1111/jiec.12174
41. Basic Information about Landfill Gas. EPA. https://www.epa.gov/lmop/basic-information-about-landfill-gas. Published June 5, 2020. Accessed July 28, 2020.
42. About the Sustainable Development Goals – United Nations Sustainable Development. United Nations. https://www.un.org/sustainabledevelopment/sustainable-development-goals/. Accessed July 28, 2020.
43. Neff RA, Spiker ML, Truant PL. Wasted Food: U.S. Consumers' Reported Awareness, Attitudes, and Behaviors. *Plos One*. 2015;10(6). doi:10.1371/journal.pone.0127881
44. Lipinski B. Installment 2 of" creating a sustainable food future": Reducing food loss and waste. World Resources Institute (WRI); 2013.
45. Coleman-Jensen A, Gregory C, Singh A. Household Food Security in the United States in 2013. *SSRN Electronic Journal*. 2014. doi:10.2139/ssrn.2504067

46. Kirkpatrick SI, Tarasuk V. Food Insecurity Is Associated with Nutrient Inadequacies among Canadian Adults and Adolescents. *The Journal of Nutrition*. 2008;138(3):604-612. doi:10.1093/jn/138.3.604
47. Hanson KL, Connor LM. Food insecurity and dietary quality in US adults and children: a systematic review. *The American Journal of Clinical Nutrition*. 2014;100(2):684-692. doi:10.3945/ajcn.114.084525
48. HHS Office, Council on Sports. Dietary Guidelines for Americans. HHS.gov. https://www.hhs.gov/fitness/eat-healthy/dietary-guidelines-for-americans/index.html. Published January 26, 2017. Accessed May 17, 2020.
49. Seligman HK, Laraia BA, Kushel MB. Food Insecurity Is Associated with Chronic Disease among Low-Income NHANES Participants. *The Journal of Nutrition*. 2009;140(2):304-310. doi:10.3945/jn.109.112573
50. Chaparro MP, Zaghloul SS, Holck P, Dobbs J. Food insecurity prevalence among college students at the University of Hawai'i at Mānoa. *Public Health Nutrition*. 2009;12(11):2097-2103. doi:10.1017/s1368980009990735
51. Gaines A, Robb CA, Knol LL, Sickler S. Examining the role of financial factors, resources and skills in predicting food security status among college students. *International Journal of Consumer Studies*. 2014;38(4):374-384. doi:10.1111/ijcs.12110
52. Maroto ME, Snelling A, Linck H. Food Insecurity Among Community College Students: Prevalence and Association With Grade Point Average. *Community College Journal of Research and Practice*. 2014;39(6):515-526. doi:10.1080/10668926.2013.850758
53. Morris L, Smith S. The Prevalence of Food Security and Insecurity Among Illinois University Students Response Letter. *Journal of Nutrition Education and Behavior*. 2016;48(9):680. doi:10.1016/j.jneb.2016.07.017
54. Patton-López MM, López-Cevallos DF, Cancel-Tirado DI, Vazquez L. Prevalence and Correlates of Food Insecurity Among Students Attending a Midsize Rural University in Oregon. *Journal of Nutrition Education and Behavior*. 2014;46(3):209-214. doi:10.1016/j.jneb.2013.10.007
55. Payne-Sturges DC, Tjaden A, Caldeira KM, Vincent KB, Arria AM. Student Hunger on Campus: Food Insecurity Among College Students and Implications for Academic Institutions. *American Journal of Health Promotion*. 2017;32(2):349-354. doi:10.1177/0890117117719620
56. Bruening M, Argo K, Payne-Sturges D, Laska MN. The Struggle Is Real: A Systematic Review of Food Insecurity on Postsecondary Education Campuses. *Journal of the Academy of Nutrition and Dietetics*. 2017;117(11):1767-1791. doi:10.1016/j.jand.2017.05.022
57. Goldrick-Rab, S., Richardson, J., Schneider, J., Hernandez, A., & Cady, C. Still hungry and homeless in college. *Wisconsin HOPE Lab*.2018. *Available online: http://wihopelab. com/publications/Wisconsin-HOPE-Lab-Still-Hungry-and-Homeless. pdf (accessed on 25 July 2018)*.
58. Mcarthur LH, Ball L, Danek AC, Holbert D. A High Prevalence of Food Insecurity Among University Students in Appalachia Reflects a Need for Educational Interventions and Policy Advocacy. *Journal of Nutrition Education and Behavior*. 2018;50(6):564-572. doi:10.1016/j.jneb.2017.10.011

59. Hunt RS. UMD's food pantry is fundraising for a $1 million upgrade. The Diamondback. https://dbknews.com/2018/09/19/umd-campus-pantry-food-insecurity-sga-dining-services/. Published 2018. Accessed July 28, 2020.
60. Zein AE, Shelnutt KP, Colby S, et al. Prevalence and correlates of food insecurity among U.S. college students: a multi-institutional study. *BMC Public Health*. 2019;19(1). doi:10.1186/s12889-019-6943-6
61. Bringezu, S, & Bleischwitz, R. *Sustainable resource management: global trends, visions and policies*. 2017. Routledge.
62. USDA, "Loss Adjusted Food Availability Documentation," December 30, 2016, Retrieved From www.ers.usda.gov/data-products/food-availability-per-capita-datasystem/loss-adjusted-food-availability-documentation/
63. United States Environmental Protection Agency [EPA]. (n.d.). Loss-Adjusted Food Availability Documentation. Retrieved From https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/loss-adjusted-food-availability-documentation/
64. Langley J, Yoxall A, Heppell G, et al. Food for Thought? — A UK pilot study testing a methodology for compositional domestic food waste analysis. *Waste Management & Research*. 2009;28(3):220-227. doi:10.1177/0734242x08095348
65. Betz A, Buchli J, Göbel C, Müller C. Food waste in the Swiss food service industry – Magnitude and potential for reduction. *Waste Management*. 2015;35:218-226. doi:10.1016/j.wasman.2014.09.015
66. Ranganathan J, Vennard D, Waite R, Dumas P, Lipinski B, Searchinger TI. Shifting diets for a sustainable food future. World Resources Institute. 2016 Jun.
67. US Department of Agriculture, Agricultural Research Service. 2016. Nutrient Data Laboratory. USDA National Nutrient Database for Standard Reference, Release 28 (slightly revised). Version Current: May 2016. http://www.ars.usda.gov/nea/bhnrc/mafcl
68. Venkat K. Comparison of Twelve Organic and Conventional Farming Systems: A Life Cycle Greenhouse Gas Emissions Perspective. *Journal of Sustainable Agriculture*. 2012;36(6):620-649. doi:10.1080/10440046.2012.672378
69. US EPA, "Food Recovery Hierarchy Sustainable Management of Food US EPA - www.epa.gov/sustainablemanagement-food/food-recovery-hierarch
70. Save The Food. https://savethefood.com/. Accessed July 28, 2020.
71. Love Food Hate Waste. https://www.lovefoodhatewaste.com/. Accessed July 28, 2020.
72. Food Loss and Waste Protocol, flwprotocol.org/.
73. Hugo Valin et al., "The future of food demand: understanding differences in global economic models," Agricultural Economics 45 (2014) 1 P. 51-67.
74. US EPA, Inventory of Greenhouse Gas Emissions and Sinks: 1990-2014, EPA 430-R-16-002, (April 2016) www.epa.gov/ghgemissions/inventory-usgreenhouse-gas-emissions-and-sinks-1990-2014.
75. Vaclav Smil, Feeding the World: A challenge for the Twenty-First Century, (Cambridge: MIT Press, 2001) P.237.
76. Freedman MR, Brochado C. Reducing Portion Size Reduces Food Intake and Plate Waste. *Obesity*. 2009;18(9):1864-1866. doi:10.1038/oby.2009.480

77. Florentino B. De La Cruz and Morton A. Barlaz, “Estimation of Waste Component-Specific Landfill Decay Rates Using Laboratory-Scale Decomposition Data.” Environmental Science & Technology, 44(May 2010):12, P.4722-4728 doi:10.1021/es100240r.
78. Alliance FW. Analysis of US Food Waste Among Food Manufacturers, Retailers, and Restaurants,(2016).
79. Hungry Harvest. https://shop.hungryharvest.net/. Accessed July 28, 2020.
80. Grocery Delivery for Organic Food, Fresh Produce & More. https://www.imperfectfoods.com/. Accessed July 28, 2020.
81. Food Recovery Network. https://www.foodrecoverynetwork.org/. Accessed July 28, 2020.
82. Come fight food waste with us. | Too Good To Go. https://toogoodtogo.org/en. Accessed July 28, 2020.
83. OCE: U.S. Food Waste Challenge: Resources: Recovery/Donations. USDA. https://origin.www.usda.gov/oce/foodwaste/resources/donations.htm. Accessed July 28, 2020.
84. Feenstra G. Creating space for sustainable food systems: Lessons from the field. Agriculture and human values. 2002 Jun 1;19(2):99-106.
85. Thiagarajah K, Getty VM. Impact on Plate Waste of Switching from a Tray to a Trayless Delivery System in a University Dining Hall and Employee Response to the Switch. *Journal of the Academy of Nutrition and Dietetics*. 2013;113(1):141-145. doi:10.1016/j.jand.2012.07.004
86. Quested TE, Parry AD, Easteal S, Swannell R. Food and drink waste from households in the UK. *Nutrition Bulletin*. 2011;36(4):460-467. doi:10.1111/j.1467-3010.2011.01924.x
87. Derqui B, Fernandez V, Fayos T. Towards more sustainable food systems. Addressing food waste at school canteens. *Appetite*. 2018;129:1-11. doi:10.1016/j.appet.2018.06.022
88. Shanks CB, Banna J, Serrano EL. Food Waste in the National School Lunch Program 1978-2015: A Systematic Review. Journal of the Academy of Nutrition and Dietetics. 2017;117(11):1792-1807.doi:10.1016/j.jand2017.06.008
89. Byker CJ, Farris AR, Marcenelle M, Davis GC, Serrano EL. Food waste in a school nutrition program after implementation of new lunch program guidelines. J Nutr Educ Behav. 2014;46(5):406-411.
90. Ansari WE, Stock C, Mikolajczyk RT. Relationships between food consumption and living arrangements among university students in four European countries - A cross-sectional study. *Nutrition Journal*. 2012;11(1). doi:10.1186/1475-2891-11-28
91. Nutrient Recommendations: Dietary Reference Intakes (DRI). NIH Office of Dietary Supplements. https://ods.od.nih.gov/Health_Information/Dietary_Reference_Intakes.aspx. Accessed May 17, 2020.
92. Mirosa M, Loh J, Spence H. The Possibilities of Reducing Food Choice to Improve the Performance of College Foodservices. *Journal of the Academy of Nutrition and Dietetics*. 2016;116(7):1163-1171. doi:10.1016/j.jand.2015.12.019
93. Rethink Food Waste. ReFED. https://www.refed.com/analysis?sort=economic-value-per-ton. Accessed May 17, 2020.

94. Food Waste FAQs. USDA. https://www.usda.gov/foodlossandwaste/faqs. Accessed May 17, 2020.
95. Food loss and waste and food security. *Food and Agriculture Organization of the United Nations Food waste | Technical Platform on the Measurement and Reduction of Food Loss and Waste | Food and Agriculture Organization of the United Nations*. 2019:1-26. doi:10.4337/9781788975391.00006
96. International Food Policy Research Institute (Ifpri). Global Nutrition Report 2016 From Promise to Impact Ending Malnutrition by 2030 Summary. 2016. doi:10.2499/9780896299948
97. ReFED. *A Roadmap to Reduce Food Waste by 20 Percent*. 2016 www.refed.com. Accessed April 3rd 2020.
98. Werf P, Seabrook JA, Gilliland JA. Food for naught: Using the theory of planned behaviour to better understand household food wasting behaviour. *The Canadian Geographer / Le Géographe canadien*. 2019;63(3):478-493. doi:10.1111/cag.12519
99. Ajzen I. The theory of planned behavior. *Organizational Behavior and Human Decision Processes*. 1991;50(2):179-211. doi:10.1016/0749-5978(91)90020-t
100. Howell, D. "Statistical methods for psychology Thomson Wadsworth." *Belmont, CA* (2007): 1-739.
101. Tabachnick, Barbara G., Linda S. Fidell, and Jodie B. Ullman. *Using multivariate statistics*. Vol. 5. Boston, MA: Pearson, 2007.
102. Principato L, Secondi L, Pratesi CA. Reducing food waste: an investigation on the behaviour of Italian youths. *British Food Journal*. 2015;117(2):731-748. doi:10.1108/bfj-10-2013-0314
103. Come fight food waste with us. | Too Good To Go. https://toogoodtogo.com/en-us. Accessed July 19, 2020.