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Ethics of Food Resource Consumption

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Abstract
Food waste is a global-scale issue that can no longer be ignored. Misuse of resources has caused large amounts of food waste in the past that results in a waste of resources such as fossil fuels, water, land, and produces excess greenhouse gasses in the process. Alternatives exist for reuse and recapturing of the potential trapped within our wasted food resources. Processes such as composting, biogas, chemical conversion, animal feed production, and other recycling efforts can be implemented in areas where reducing food waste seems to be difficult. Increasing industrial efficiency may also reduce waste. New and emerging control technologies have helped reduce agricultural inputs and also reduce waste while processing. Raising consumer awareness of these issues may push buyers in the direction of environmental and economic harmony where a balance can be kept between consumers and the industry. If growing future demands of developing countries cannot be met government intervention may have to take place. However, these systems are expensive and take the time to implement. Focusing on consumer waste reduction and industrial efficiency must be a priority to reduce food waste in the near future.

Keywords
Food waste, supply chain, pre-consumer, post-consumer, composting, landfill, incineration

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Ethics of Food Resource Consumption

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ABSTRACT. *Food waste is a global-scale issue that can no longer be ignored. Misuse of resources has caused large amounts of food waste in the past that results in a waste of resources such as fossil fuels, water, land, and produces excess greenhouse gasses in the process. Alternatives exist for reuse and recapturing of the potential trapped within our wasted food resources. Processes such as composting, biogas, chemical conversion, animal feed production, and other recycling efforts can be implemented in areas where reducing food waste seems to be difficult. Increasing industrial efficiency may also reduce waste. New and emerging control technologies have helped reduce agricultural inputs and also reduce waste while processing. Raising consumer awareness of these issues may push buyers in the direction of environmental and economic harmony where a balance can be kept between consumers and the industry. If growing future demands of developing countries cannot be met government intervention may have to take place. However, these systems are expensive and take the time to implement. Focusing on consumer waste reduction and industrial efficiency must be a priority to reduce food waste in the near future.*

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Introduction

Over the past 10,000 years, the world's food production has undergone enormous changes and agriculture has played a central role in that process. The main focus and worries have always been centered on making improvements in food production to feed an exponentially growing population successfully. According to the United Nations, the world population will reach 9.3 billion by 2050 and most of this growth will occur in developing countries. The challenge will be not only to increment about 70% the food production but also to achieve the goal based on sustainable agriculture practices (FAO, 2009; Pelletier et al., 2010; Tilman et al., 2001; United Nations, 2011). Fortunately, the advances in agricultural, biotechnological, and industrial processes have led into an era of abundant food for the current population, but as consequence ecosystem degradation, loss of natural resources and other environmental impacts have occurred. However, the access and distribution of world's food are unequal and about nine million people die of hunger per year, and 800 million are undernourished. Production of food that will not be consumed will result in unnecessary CO_2 emissions and loss of economic value. In the food processing industries around 30% of the incoming raw materials becomes waste rather than a value added product (Lowe and Buckmaster, 1995).

Misuse of food resources is caused by a variety of different factors. Both pre- and post-consumer food waste is prevalent. In developed countries the post-consumer food waste is substantially higher as food is seen as "undesirable", and is disposed of for being inferior. A lack of education also causes consumers in developed countries to waste more food when they do not understand the difference between "Use-by" and "Sell-by" dates. Pre-consumer waste is also very common in the form of processed food products. In developing countries the pre-consumer waste is very high, but mostly in the form of spoilage of stored goods as inadequate conditions and infrastructure are in place to store food resources.

Wasted resources are not only food, but also in the actual assets allocated to food production, harvest, transport, and any processing associated with wasted food products. This overuse of resources to gain

food stocks creates additional ecological harm in the form of water and land use, GHGs, and other forms of pollution. These issues, in turn, will make it more difficult to produce additional food in the future, thereby robbing the system of additional efficiency and a significant portion of any sustainability that would be associated with it.

Energy from eaten food supports physical activities and basal metabolism; on average a healthy adult consumes about 10,460 joules per day, considering a 312 million population in the U.S. 1.19×10^{15} joules of energy food are demanded per year. About 10 units of nonrenewable energy are needed to produce one unit of food energy, hence feeding the United States population requires 10% of the total energy consumption (Webber, 2012). The amount of food intended for human consumption wasted has progressively increased in the last decades, from 30% in 1974 to almost 40% in recent years (Hall et al., 2009). Considering agriculture uses about 65% of the U.S. land (Nickerson et al., 2011) and consumes approximately 70% of the freshwater (Postel et al., 1996). Then 26% of the total U.S. area is used to produce food that will never be eaten, and 28% of water use is accounted for by wasted food. In 2014, The United States consumed a total of 6.97 billion barrels of petroleum products and about 300 million barrels account for wasted food (Hall et al., 2009). However, consumers may not easily associate any of the previously mentioned environmental impacts, energy consumption and emissions behind food production. It's more obvious to think about emanations when driving a car than when eating a plate of food. (Lappé, 2010).

In the past few decades, little attention has been paid to food wastes as potential inputs for developing new products and also to venture into new markets. Currently, food waste recovery focuses on recapturing components and/or developing novel products with a market value (Galanakis, 2012, 2013; Galanakis and Schieber, 2014). Reuse and recovery of food waste are critical not only to cause a reduction in food waste but also in energy and raw materials, causing an improvement in the performance of the whole food system.

Current Options for Food Waste Treatment

Traditionally, most of the food waste from industries and household has been landfilled. After the deposition of food waste in a landfill, microorganisms will start consuming carbon that the food contains, resulting in decomposition. Methane will be produced as a result of the anaerobic conditions that are prevalent in landfills. As the organic matter is decomposed over time, approximately 50% of methane and 50% of carbon dioxide will be emitted leaving about 1% of trace elements (FAO, 2013). However, due to the closure of landfills sites and environmental regulations the industries are looking for other options such as composting (Schaub and Leonard, 1996). Composting is a natural aerobic biochemical process in which the thermophilic microbes transform organic materials into a soil-like product that is stable (Miller, 1993) and it can reduce the volume of organic products by up to 40%, and it can turn into a product generating revenue (Kashmanian, 1995). Fermentation is another opportunity for wasted food where it can be used to produce biohydrogen and fatty acids which are used as human and animal feed additives (Han and Shin, 2004, Lin et al., 2013).

Due to ruminants different digestive systems when compared humans, feeding the food waste to cattle and sheep is not prohibited (Hoelting and Walker, 1994). The food waste that is not fit for human consumption, such as vegetable peelings can be used for animal consumption. It also avoids the use of additional natural resources as feed for animals (FAO, 2013).

Governments, organizations, and consumers can no longer ignore the potential behind the food wastes to improve the sustainability of the food production systems. The present study conducts a literature review on the food losses in the U.S. among the different levels of the food supply chain, identifying its weaknesses and strengths to evaluate possible recommendations and solutions to increase the efficiency of the system by recycling or reusing food wastes.

Management Styles

There exist two very different countermeasures for dealing with food waste. Waste can be addressed before it happens; waste reduction or elimination is a preferred method of management. Waste can also

be managed after it is created and then used for other goods or processes. The first is a more preferred method that can be implemented mostly via cultural change. The latter is far more wasteful of resources are still expended to grow and process the food, as discussed.

One common factor between both of these styles will be debated now and can be kept in mind for both of the following sections. Technology is this major factor; increasing complexity and our use of technology can play vital roles in both reduction and elimination of waste as well as any food waste processing methods we may utilize. Attempting to use the newest and most efficient technologies is a goal that should be ingrained into our mind when considering the management of our resources.

Pre Consumer and Post Consumer wastes

In the food supply chain, food waste can be subcategorized into pre-consumer and post-consumer wastes (Pfaltzgraff et al., 2013). These wastes result in a waste of resources for the production and distribution of food, along with water, land, fertilizers, energy, pesticides and capital. According to National Resources Defense Council, approximately 40% of the food produced in the United States is lost in the form of waste during its processing and distribution by retailers, restaurants and consumers. Reducing these pre-consumer and post-consumer food waste is a crucial step, and the current initiatives to handle these losses and waste are discussed in the paper.

Food Waste Reduction and Elimination

Much more food is wasted in the developed world than the developing countries based on a waste per-capita basis (FAO, 2013). Food waste occurs in the form of crops left in the field, transport losses, food disposed of during packaging and poor stock management (Parfitt et al., 2010). This waste of food is inevitable, but the majority of it can be preventable. It has been noted that food consumption is one of the most polluting and resource demanding activities within a household (Carlsson-Kanyama, 1998). Though the technology has improved substantially in a supply chain to keep food lasting longer, an

unnecessarily large amount of food is still wasted. Furthermore, there is a lack of understanding of the actual scale of food waste at both the national and global levels by the average consumer (Parfitt et al., 2010). As mentioned, this management style is far preferred to waste processing as it negates nearly all of the wasted resources associated with food production.

Food waste reduction can be accomplished in different ways. Cultural changes in developed countries would likely see the largest impact on the food waste issue at hand. Even small changes could have a greater impact if everyone were to conform. Simple lifestyle changes such as buying fewer groceries at a time and keeping less on hand, being more mindful of consuming leftovers, and consuming fresh goods before they spoil would all have a large impact on residential food waste. Each of these items is seemingly very simple, yet very few consumers currently practice these approaches.

Education is essential for significant cultural changes associated with food waste. One of the largest barriers is the average person's lack of information on the subject. Being mindful of how much impact certain foods have on our ecosystem is also a major factor that could be used to help educate the populous. Knowing that beef takes two and a half times more energy to produce than pork, and seven times more than chicken may make some consumers reconsider the steak they're about to purchase.

This reduction can also come about in the form of government laws and mandates. Government regulations are typically aimed more at businesses and industry; this can also be extremely effective, but often sees more resistance as it is seen as "costly." These regulations can be very simple, for example, the French government has recently made it illegal for grocery stores to throw away unused food (Peterson, 2015). Instead, it is donated to the needy when it is about to expire. This nationwide mandate is going to save thousands of pounds of food every year and help those less fortunate in the process.

Food Waste Processing

Processing food waste into other usable products should come as a backup to reducing food waste overall. Almost all of the waste processing techniques we will discuss later on could all be done with a much cheaper and less wasteful input product. However, rather than landfilling food waste, these processes are much more beneficial as they produce useful good.

The category of food waste processing consists of many different processes, such as anaerobic digestion, ethanol fermentation, incineration, pyrolysis, and gasification. Some potential infrastructure issues arise with doing these processes, such as sorting food from garbage or one food waste from another so that certain processes can be conducted. The intricacies of what is involved with each of these systems will be discussed later on.

Composting

Composting is a good alternative solution for food solid wastes going into landfilling areas. It is a natural aerobic biochemical process in a stable soil-like product is formed by transformation of organic materials by the action of thermophilic microbes such as fungi, bacteria and protozoa. Factors influencing the microbial activity are temperature, pH, moisture content, particle size and carbon to nitrogen ratio (Miller, 1993). Microorganisms require water, like all other living organisms for their activity and the moisture content, should be maintained at 40-60% (Leonard and Ramer, 1994). If the process is carried out properly, it results in temperatures that can deactivate pathogens, also reducing the volume of the organic products by 40% (Kashmanjan, 1995). By the action of these microorganisms, food wastes are transformed into more stable products, improving the recycling of nutrients and reducing methane emissions. The product obtained after composting can be used to improve soil properties such as porosity, infiltration, and restore organic materials among others. (Galanakis, 2015; Gunders, 2012). This process requires suitable physical and chemical properties and good management to make certain that suitable processing conditions are maintained. Developing composting programs in schools and communities to teach and promote composting at homes could lead into reductions in food wastes going into landfills.

Animal Feed

The use of food wastes as animal feed is one of the most employed and popular practices. Humans are generating millions of pounds of organic waste annually and, as mentioned, most of it is landfilled. Therefore, using this organic waste as animal feed is an appealing alternative that demands greater consideration. Valorization of these vegetable by-products for feed formulation would reduce the environmental effect and also increase resource efficiency. However, the feasibility of this organic waste as animal feed is limited because of certain disadvantages. For instance, it has a higher moisture content of 80% or more that makes handling more difficult and can stimulate the growth of microorganisms (Garcia et al., 2005). Moreover, technology applied to produce dry feeding for livestock have been improving and increasing during the last decades. Even though the dehydration of food waste is still an expensive option, it could be an alternative in the future for reusing restaurant food wastes, as these are high in nutrients and are desirable for feeding livestock. Furthermore, waste disposals such as landfills are becoming scarce, and consequently more expensive, thus recycling food waste to produce animal feed, once again, is a possible solution (Myer et al., 1999).

Biofuel conversion methods

Mixed food wastes are rich in carbohydrates, proteins, and minerals; thus, they are an excellent input for the production of biofuels and bio-based chemicals through microorganisms such as bacteria, yeast, fungi or algae. In comparison to other uses for food wastes, this novel process maximizes the recycling of nutrients and energy, and also reduces treatment costs and required time to convert waste to a valued good. There are few options at the moment for the transformations of food waste into bioenergy, but promising approaches have been made.

It is possible to develop cost-effective methods for production of biofuel using lipids and carbohydrates produced from food waste since it is considered as zero cost material. Food waste is mainly composed of carbohydrate polymers such as starch, cellulose, lignin, proteins, organic acids and lipids. Food waste contains protein and sugar contents ranging from 4 to 22% and 35.5 to 69%

respectively. The average fat content varies around 30%, and average carbohydrate content is around 50%, depending on the type of food waste. These carbohydrates in food waste can be broken into glycoside bonds by hydrolysis. By breaking the glycosidic bonds, polysaccharides are released as oligosaccharides and monosaccharides that are more efficient for fermentation. Producing fuel from the food waste has more value compared to animal feed and electricity generation.

However, the use of food wastes to produce biofuel presents some challenges. For instance, food wastes can easily get contaminated by microorganisms, special care needs to be taken during its storage, transportation and handling (Arancon et al., 2013; Luque et al., 2013; Matsakas et al., 2015). Also as discussed, food waste varies considerably in its chemical content which adds a degree of uncertainty to any chemically based process.

Landfilling

Landfilling is defined as the disposal, press, and embankment fill of wastes at specific sites, and it is one of the cheapest solid waste disposal options. Consequently, it is one of the most common in many communities. This applies to both developed and non-developed nations. After the deposition of food waste into a landfill, microorganisms will start consuming carbon that the food contains, resulting in decomposition. Methane will be produced as a result of the anaerobic conditions that are prevalent in landfills. In landfills, due to the anaerobic conditions and decomposition of organic matter, nearly 50% of methane is produced along with 50% of carbon dioxide and almost 1% of trace elements (FAO, 2013). Government policies should be focused on reducing to a minimum the amount of food going into landfilling sites to prevent the pollution of groundwater and soil (Galanakis, 2015).

Reducing Overall Waste

Since some of the common areas of concern are now noted we may begin by discussing alternatives and solutions to the food waste issues that have been discussed. A chronological focus will be used to guide us through the options laid out before us; that is, working from field to processor, to consumer.

We will first discuss some of the technology that has been implemented in recent years and determine how it has affected the industry. Cultural and legal changes will also be discussed as they may provide a much-needed improvement in the area of food waste.

A considerable amount of food is lost at the producer level, including wasted grain in the field and dead or discarded animals. Standardization in terms of quality, size and varieties demanded by stakeholders, like retailers and wholesalers, is the main reason for a large percentage of the edible food wasted at this level (Halloran et al., 2014).

There are two major sources of food losses at this level: food that is never harvested and harvest/post-harvest loss. Some factors that could lead into non-harvested areas are bad weather conditions, for instance, periods of heavy rains causing inappropriate soil conditions; market variations, falls in product price may cause growers to leave unharvested areas; damage caused by pests and/or diseases (Gunders, 2012).

Even when food is harvested there are losses caused by mechanical damage, spillage and/or degradation during harvest operations, crop classification, primarily storage, packing, handling, and transportation (Gustavsson et al., 2011; Kummu et al., 2012). However, farmers have seen vast improvements in the technology of their operations over the last few decades. Not only have tractors and harvesters seen increases in fuel economy, but they also tend to do a more efficient job of the task at hand; be it harvesting corn, soybeans, or any other crop. Through various technological improvements farmers have seen decreases in fuel usage, which decreases overall cost and greenhouse gasses, as well as increases in harvest efficiency as less food is wasted by being sent out the wrong port from the harvester. Wasting less food during harvest puts processors and consumers ahead of the game to begin the cycle.

From the farm, many foods see long periods of storage. Increasing technology has also increased our storage length and success rate in many industries. Improved refrigeration and freezer units have

increased efficiency and decreased power usage. In the case of grain, farmers are beginning to understand what they can and cannot do with their grain bins to decrease spoilage, and co-ops and processors are always applying pressure to producers to deliver high quality goods; storage plays in integral role in assuring high-quality goods stay as such.

Industry level food waste could be occurring due to profit-maximizing behavior. Hence, on one hand food waste reflects the existing technology and on the other hand might be the result of regulatory restrictions, with certain parts of the carcass not allowed for use in production.

Food processors have seen the largest amount of pressure to reduce waste in the recent past. As these companies process fresh foods into consumer goods, they often create high volumes of waste. This waste tends to be food that is either of poorer quality or is 'trimmings'. The poorer quality food is often labeled as a lower grade and sold in bulk, or used as an additive in another product. However, much of the trimmings and cuttings find themselves in a landfill and become waste. These wastes could easily be used for other processes or products and this is an area in which a simple cultural or mandated change can be very effective. Many companies already find it beneficial to sell or give away parts of their food waste stream to compost facilities or animal producers. Recycling the energy within this wasted food is far more efficient than tossing it into a landfill where it provides no added value. Many producers already practice this idea; however most do not as it is seen as an unnecessary step that costs money. However, it may take government intervention to declare that throwing food waste, even if seen as undesirable to humans, is not beneficial for business or the environment.

In 2008, the estimated food loss at the retail level in the United States was about 19 billion kilograms (42 billion pounds), valued at $15 billion and equivalent to $50 per capita (Buzby et al., 2011). However, as retailers have a direct contact with their upper and lower levels in the supply chain they are responsible for a bigger fraction of the losses among the system, but those are not easily measurable (Gunders, 2012). Losses at this level are due to overstock of products, expired "sell by" dates,

distribution and handling damages, natural deterioration and shrinkage, mold and pest infestations, improper or damaged packaging, inappropriate stock rotation, and others (Buzby et al., 2011).

The last area in which improvements can be made is the consumer category. Consumers waste massive amounts of food every year for a multitude of reasons. In 2008 American families and the food service industry wasted about 84 pounds per capita of fresh and processed vegetables and fruits. Moreover, the consumer level is responsible for losses valued at $28 billion, 86 percent higher than those at the retail level (Buzby et al., 2011). Preferences for a certain quality of food could be the reason for the occurrence of food waste at the household level. An example of this is leftovers from a meal. By changing these preferences, food wastes of such kind can be reduced to some extent.

The main impact on this level is related to perishables, because of its tendency to spoil and that they also represent a high volume of the total consumption of foods in developed countries. Other factors affecting the food service stage are the size of portions, inflexibility of chain-store management, and also pressure to maintain enough food supply to offer extensive menu choices at all times. These factors account for the four to ten percent of food purchased by the restaurant that never reaches the customer (Kantor et al., 1997). Over-buying or buying in bulk often causes food waste as food is not eaten soon enough. Leftover food in the fridge is often seen as the second rate and is wasted very commonly. Last, the price of food is low enough in many developed places that wasting it doesn’t have a large monetary impact on consumers.

Many of these concerns can be addressed with simple cultural changes in the home. Through simple education of the masses, people are already becoming aware of the current state of affairs and how much of our food goes wasted every day. By continuing this fight, consumers can make the educated decision on what, and how much; they should buy for their family. Many consumers are still unaware of the food waste issue we face, hopefully, through education, these people will get the information they need to make a proper and informed decisions about their food sources and waste.

Conclusions and Recommendations

This study has compiled reports on food losses and waste in the United States supply food chain. Potential and already implemented solutions to reduce the amount of waste food have been discussed and reported. The main challenge is still the production of enough food for a still increasing world population, but now the focus on succeeding in our food security goals also includes developing and implementation of more sustainable practices throughout the entire food supply system.

In conclusion, food waste is a major issue today for multiple reasons. The actual quantity of food that never reaches the tables can be reduced with the higher engagement of all the parts in the food supply chain to provoke a change in the behaviors of those who are causing our current amount of food waste. Informative campaigns about the monetary and nonmonetary impact behind food loss would lead to a better understanding of the consumer, whom would have a greater motivation to waste less food. Many of the causes for food waste can be addressed with simple education and reformation of our cultural ideals surrounding food and food waste. Examples of forced cultural changes through mandates are given with the example of the French government. By making disposal of food illegal, the government is causing a forceful change in the way people treat this valuable commodity. This forced change is not a far-fetched idea and could be implemented with great success in many countries.

To recap; the food wasted has many negative impacts including increased land and water use, an increase in GHG, and other wasted resources. Most of these resources are not recovered even with good end-of-life treatment for food waste. For this reason, it is best to reduce waste overall and save conversion methods of food to other goods for only when truly necessary.

Conversion methods, which are once again less preferred, should only be used when food can no longer be consumed safely. Some of the more feasible conversion methods discussed include composting, animal feed, and biofuel conversion of food waste. Each of these conversion methods could be tied directly into the supply chain to provide a more efficient and self-sustaining method of food production. Compost produced can be used to grow vegetables at home or on small farms. Animal feed

from food waste is a direct conversion back into the food production stream. Lastly, biofuels are made from food waste can be used to fuel farm equipment or transportation equipment to reduce cost and dependency on oil for such needs. As can be seen, there is no use in delaying action in correcting our food waste issues.

Research on new alternatives for food waste management might bring possibilities for technical and scientific development. Reducing losses would also have several impacts on water, energy and land use, as well as decreasing environmental impact.

References

Arancon, R. A. D., Lin, C. S. K., Chan, K. M., Kwan, T. H., & Luque, R. (2013). Advances on waste valorization: new horizons for a more sustainable society. *Energy Science & Engineering*, *1*(2), 53-71.

Buzby, J. C., Hyman, J., Stewart, H., & Wells, H. F. (2011). The value of retail-and consumer-level fruit and vegetable losses in the United States.*Journal of Consumer Affairs*, *45*(3), 492-515.

Carlsson-Kanyama, A. (1998). Climate change and dietary choices—how can emissions of greenhouse gases from food consumption be reduced? *Food policy*, *23*(3), 277-293.

FAO, P. (2010). The state of food insecurity in the world 2009: economic crises–impacts and lessons learned.

FAO, 2013. Toolkit: Reducing the food wastage footprint. http://www.fao.org/docrep/018/i3342e/i3342e.pdf

Galanakis, C. M. (2012). Recovery of high added-value components from food wastes: conventional, emerging technologies and commercialized applications. *Trends in Food Science & Technology*, *26*(2), 68-87.

Galanakis, C. M. (2013). Emerging technologies for the production of nutraceuticals from agricultural by-products: a viewpoint of opportunities and challenges. *Food and Bioproducts Processing*, *91*(4), 575-579.

Galanakis, C. M. (Ed.). (2015). *Food Waste Recovery: Processing Technologies and Industrial Techniques*. Academic Press.

Galanakis C.M., Schieber A. (2014): Editorial of Special Issue on “Recovery and utilization of valuable compounds from food processing by-products”. *Food Research International*, 65: 299–230.

Garcıa, A. J., Esteban, M. B., Márquez, M. C., & Ramos, P. (2005). Biodegradable municipal solid waste: Characterization and potential use as animal feedstuffs. *Waste Management*, *25*(8), 780-787.

Gunders, D. (2012). Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. *Natural Resources Defense Council*, 1-26.

Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A. (2011). Global food losses and food waste. *Food and Agriculture Organization of the United Nations, Rom*.

Hall, K. D., Guo, J., Dore, M., & Chow, C. C. (2009). The progressive increase of food waste in America and its environmental impact. *PloS one*,*4*(11), e7940.

Halloran, A., Clement, J., Kornum, N., Bucatariu, C., & Magid, J. (2014). Addressing food waste reduction in Denmark. *Food Policy*, *49*, 294-301.

Han, S. K., & Shin, H. S. (2004). Biohydrogen production by anaerobic fermentation of food waste. *International Journal of Hydrogen Energy*,*29*(6), 569-577.

Hoelting, F. B., & Walker, P. M. (1994). Illinois State University to recycle dining center food and paper wastes into cattle feed. *Bioresource technology*, *49*(1), 89-92.

Kantor, L. S., Lipton, K., Manchester, A., & Oliveira, V. (1997). Estimating and addressing America's food losses. *Food review*, *20*(1), 2-12.

Kashmanian, R. M. (1995). Poultry industry finds added value in composting. *BioCycle*, *36*(1), 55-57.

Kummu, M., De Moel, H., Porkka, M., Siebert, S., Varis, O., & Ward, P. J. (2012). Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. *Science of the Total Environment*, *438*, 477-489.

Lappé, A. (2011). *Diet for a hot planet: the climate crisis at the end of your fork and what you can do about it*. Bloomsbury Publishing USA.

Leonard, J., and Ramer, S. (1994). Physical properties of compost – What do we know and why do we care? *Environmental Canada*, 25-44.

Lin, C. S. K., Pfaltzgraff, L. A., Herrero-Davila, L., Mubofu, E. B., Abderrahim, S., Clark, J. H., ... & Thankappan, S. (2013). Food waste as a valuable resource for the production of chemicals, materials and fuels. Current situation and global perspective.*Energy & Environmental Science*, *6*(2), 426-464.

Lowe, E. D., & Buckmaster, D. R. (1995). Dewatering makes big differences in compost strategies. *Biocycle: Journal of composting and recycling*, (1), 78-81.

Luque, R., & Clark, J. H. (2013). Valorisation of food residues: waste to wealth using green chemical technologies. *Sustainable Chemical Processes*, *1*(1), 1.

Matsakas, L., & Christakopoulos, P. (2015). Ethanol production from enzymatically treated dried food waste using enzymes produced on-site.*Sustainability*, *7*(2), 1446-1458.

Miller, F. C., & Metting Jr, F. B. (1992). Composting as a process based on the control of ecologically selective factors. *Soil microbial ecology: applications in agricultural and environmental management*, 515-544.

Myer, R. O., Brendemuhl, J. H., & Johnson, D. D. (1999). Evaluation of dehydrated restaurant food waste products as feedstuffs for finishing pigs.*Journal of animal science*, *77*(3), 685-692.

Nickerson, C., Ebel, R., Borchers, A., & Carriazo, F. (2012). *Major uses of land in the United States, 2007*. BiblioGov.

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050.*Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *365*(1554), 3065-3081.

Pelletier, N., & Tyedmers, P. (2010). Forecasting potential global environmental costs of livestock production 2000–2050. *Proceedings of the National Academy of Sciences*, *107*(43), 18371-18374.

Peterson, L. (2015, May 26). It's Now Illegal in France for Grocery Stores to Throw Away Edible Food. Retrieved April 06, 2016.

Pfaltzgraff, L. A., Cooper, E. C., Budarin, V., & Clark, J. H. (2013). Food waste biomass: a resource for high-value chemicals. *Green Chemistry*, *15*(2), 307-314.

Postel, S. L., Daily, G. C., & Ehrlich, P. R. (1996). Human appropriation of renewable fresh water.*Science-AAAS-Weekly Paper Edition*, *271*(5250), 785-787.

Schaub, S. M., & Leonard, J. J. (1996). Composting: An alternative waste management option for food processing industries. *Trends in food science & technology*, *7*(8), 263-268.

Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, *108*(50), 20260-20264.

United Nations. (2011). World Population Prospects: The 2010 revision. New York: United Nations.

Webber, M. (2012). How to make the food system more energy efficient. *Scientific American*, *29*.