Life Cycle Assessment of a Food Service Operation in Oakland, CA

Gwantae Lee

ABSTRACT

The relationship between humans and food is very close. Humans have to eat to live, and the scale of the foodservice industry is growing. Depending on the way food is prepared and its ingredients, its impact on the environment varies. However, research on the environmental impact of food service operations is scarce. The life cycle assessment study focused on the two-year activities of running a restaurant. It includes both direct and indirect contributions. For this study, a food service operation model was developed in three stages: material production (extraction from nature and farming), transportation, and restaurant operation. Data was collected from a Korean restaurant in Oakland, CA, and former LCA studies. Between the three systems, material production contributed to hotspots in the GHG emissions of the restaurant. Producing beef was the hotspot among the entire materials used for the restaurant operation. Transportation of material and energy consumption for the operation were the other two big contributors to GHG emissions. This study presents an overview of climate change impact on the operation of a Korean restaurant. The result helps to direct potential solutions to reduce the environmental impact of the restaurant operation.

KEYWORDS

LCA, GHG emission, carbon footprint, Korean food, restaurant operation

INTRODUCTION

Human life and food have inseparable relations. We intake nutrients from food every day and keep our lives. Raw materials such as crops or livestock from farms go through various processes to arrive at our dining table. People also eat out at restaurants or buy fast food. In 2008 42% of money spent on food by people in the United States was at food service establishments (BLS 2010). According to the National Restaurant Association, sales in the restaurant and foodservice industry were $864.3 billion in 2019 but dropped to $659 billion in 2020 because of the global COVID-19 pandemic. The sales are projected to increase to $731.5 billion in 2021 (Riehle et al. year). Operating restaurants generate huge environmental impacts. Operating restaurants impact climate change, ecotoxicity, land-use change, acidification/eutrophication, and carcinogens (Baldwin et al. 2011). In the process of producing, preserving, and distributing food a considerable amount of energy is consumed contributing to total CO_2 emission (Roy et al. 2009).

Cooking food consumes huge amounts of energy and emits large amounts of greenhouse gas (Xu et al. 2015). Energy consumption and CO_2 emissions by cuisines can be varied. Depending on the food culture and the cuisines the food can be mainly focused on meat or vegetables. Also, depending on whether the ingredients are boiled, roasted, or fried, the energy consumption will be different, and the resulting carbon dioxide emissions will also be different. As such, differences affect the environmental footprint of food (Röös et al. 2015). Red meat usually needs to be cooked at a high temperature. Beef is recommended to be cooked at 62.8℃, 82℃ for chicken, 71℃ for pork (Pathare and Roskilly 2016)**.** Selection of cuisine, cooking fuel, and cookware can vary the energy consumption and GHG emissions. But there is a lack of study in the food service industry regarding the environmental impact and carbon footprint.

This study aims to find out what is the environmental impact of a Korean restaurant in Oakland especially in GHG emissions. To figure out the research question, identification of the sources and priorities of carbon footprint by the restaurant operation is needed. Furthermore, hotspot of carbon footprint from the restaurant operation will be identified. By identifying these points, a decrease in the environmental impact of Korean restaurants from the found hotspot is expected.

BACKGROUND

Study site description

The study site is a Korean restaurant located in Oakland, CA named Moobongri (MBR). MBR can be found in the back of Temescal's Koryo plaza. MBR has been open for about four years. It's part of a franchise chain that started in Los Angeles, and there's one more chain in the South Bay. MBR specializes in traditional Korean casseroles, soups, stew, and blood sausage. The majority of their served menus are mostly soup-based food either beef base broth or pork base broth which is simmered for more than 14 hours long. They are serving 45 kinds of entries in seven categories: sausage, sausage soup, soup, special, saute/casserole, chicken, cold noodles, and 12 kinds of beverages. Most of the soups are served in a hot stone bowl when it's boiling. The special menus and chickens are served on wide plastic plates that are reusable. Saute and casserole menus are served in a metal pot and a portable burner. All of the menus, and entrees, are served with rice and two or three side dishes such as Kimchi, Radish Kimchi, and Green onion Kimchi. You will be seated at the table once it's ready. A menu and a bottle of water are given to the table. Utensils and napkins are already on the table, and there are usually three containers with salt, sesame seed powder, and salted shrimp. Around 90% of their customers are Asians, mostly Korean or Chinese. The price of the entree menu per portion is around $14. The sales of MBR kept increasing until the Shelter in Place was announced by the county of Alameda on 16 March 2020. After the order from the county, sales of MBR dropped drastically. They only could accept to-go and delivery orders. The delivery was low with people's concern about being infected with COVID-19.

While working at MBR for around one year, I had the chance to see how the chefs prepare food. For the broth, they wash meat or bones several times and boil them in water for over 14 hours. Once the broth is ready, they separately pour them into a huge container and store them in the refrigerator. They also boil beef and pork for several hours and store them in the refrigerator. After they finish boiling the pork in water, some parts of the fat are cut and thrown away into the trash bin. While preparing their side dishes, Korean traditional food: Kimchi, it is required to use of tremendous amounts of water. Cabbage and radish are salted for 12hours and washed. When Kimchi is finally cooked, they are also stored in the refrigerator.

Life Cycle Assessment

Life Cycle Assessment (LCA), is a scientific analysis method to evaluate the environmental impact of a product or service to our society from natural resources extraction for manufacturing to end of life activity (Figure 1). LCA describes the environmental impacts of a product's life cycle, including climate change, stratospheric ozone depletion, ground ozone (smog) production, acidification, and toxicological stress on humans (Rebitzer et al. 2004). In other words, LCA helps us to quantify and compare the environmental impact of goods and services on our society. LCA has multiple approaches for its way such as air, water, waste, energy, and so many other things. LCA supports the process of people's environmental decisions. LCA can be applied for analyzing the source of problems from a particular product, comparing improvement variants of a product, new product designing, and choosing a number of comparable products (Finnveden et al. 2009). By comparing the result of LCA with the inputs such as energy, raw materials, disposable stuff, or others in MBR before and after the pandemic, change in the environmental impact by MBR can be measured. Also LCA can help for identification for where the greatest improvements can be made in the life cycle of MBR.

METHODS

System, Scope, Functional unit

The time frame of this study is 2 years of activities from 2020.01.01 to 2021.12.31. Every data related to material that is used for the operation of the restaurant is collected in weight or volume of its usage. The system boundary of this study is from cradle (farming of agricultural products and the production of industrial products) to serving at the restaurant (Figure 2). It includes transportation of products among the farm, producing facility, retailer, and restaurant. The farm includes farming/raising of agricultural products including beef, pork, chicken, and vegetable and production of industrial products such as beer, soda, sauces, and plastic containers. The system will be divided into three sub-systems. The first is farming or extraction of raw material and production of products. Farming begins with feed production for raising cows, pigs, and chickens. This first stage is mainly targeting GHG emissions from producing and farming of industrial products and raw materials. The second stage is transportation from the production facility to retailers and arrival at the restaurant. In the second stage, greenhouse gas emissions by the transportation section are mainly focused. The last stage is cooking and serving food using the delivered products. For the last stage, GHG emission during cooking and serving the food is mainly focused on.

The functional unit of this study is kg CO_{2e}/ $. The functional unit tells the total amount of GHG emissions per dollar of sales at the restaurant.

Data Sources & Input information

Primary data was collected from research partner interviews and invoices. The material consumption of the foodservice operation was measured through the collected two-year-long invoices. Beef, pork, chicken, vegetables, and other industrial product usage were collected from the provided invoices. Industrial products are sauces, beverages including soda and alcohol, and plastic packaging. Consumption products that are not listed on the invoice are collected by interviewing the research partner. The energy usage data (gas & electricity) was collected by suppliers.

The background data (secondary data), the life cycle inventory data of agricultural products and industrial products were taken from formerly published scientific literature and public data. Carbon emission factors from the materials listed on the invoices such as beef, pork, chicken were collected. LCA data of beef production including feed production, cattle production, packaging, and retail was collected (Asem-Hiablie et al. 2019). LCA data of pork production including feed milling, breeding, weaner-grower, grower-finisher, and meat processing was collected as well (Wiedemann et al. 2016). LCA data of chicken production including feed production, chicken breeding, and rearing, and distribution was collected (Bengtsson and Seddon 2013). Both life cycle assessments of chicken and pork production need assumptions as they are researched in Australia and MBR uses pork and chicken from the USA. LCA data of rice, cheese, onion, garlic, and octopus was collected (Clune et al. 2017). The LCA data for energy use (eGRID) was collected from the EPA website.

Impact Assessment

To determine the greenhouse gas emission associated with the operation of the restaurant, the amount of material used and emission factors of each material were collected. After multiplying the use amount and emission factor of each material, GHG emission is calculated. GHG emission is organized by the type of each material and each stage of the operation.

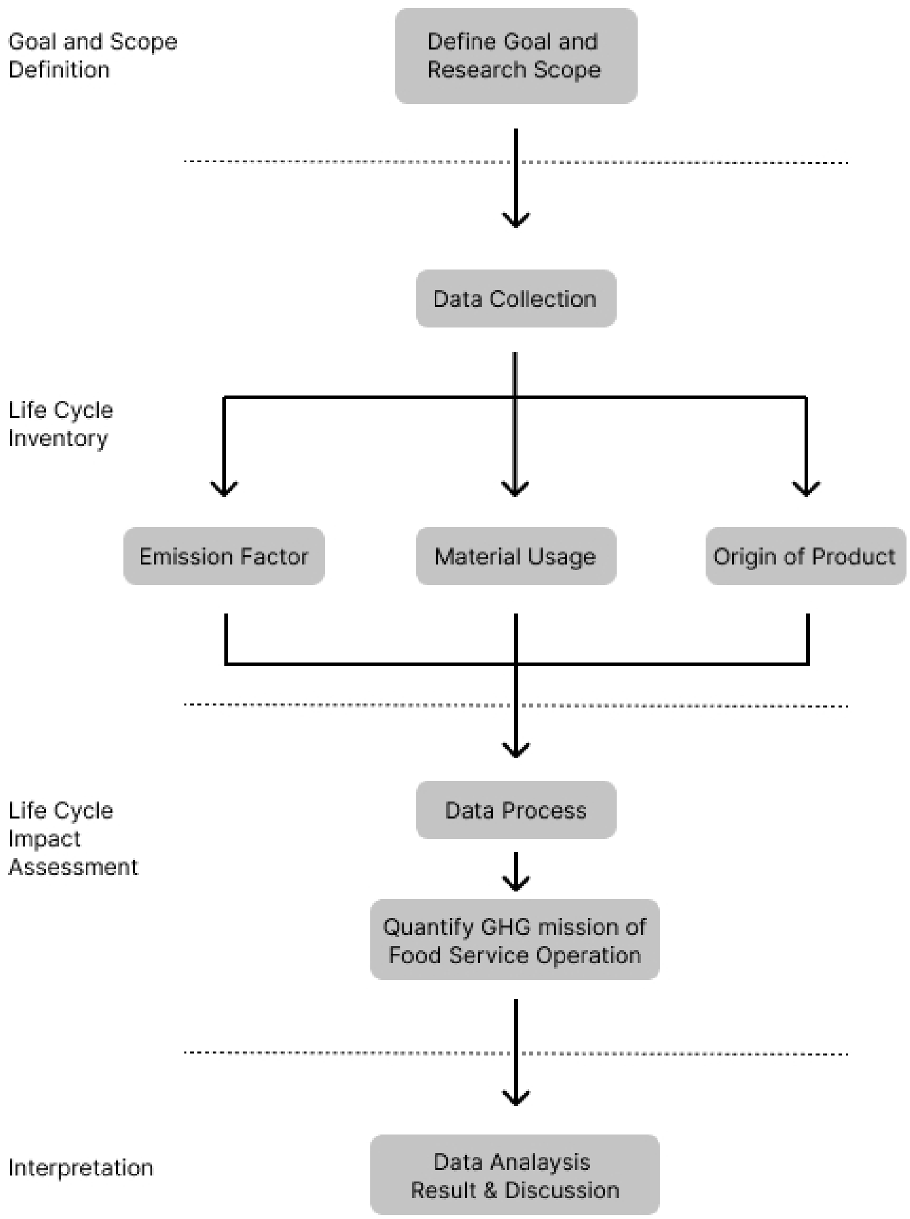

Figure 1. LCA study process. The process of this study begins with goal and scope definition which includes defining the functional unit of the research. Data regarding emission factors on materials, material usage, and origin of product are collected. GHG emissions of the food service operation is quantified once the data is processed. Based on the quantitative GHG emission results, interpretation is done.

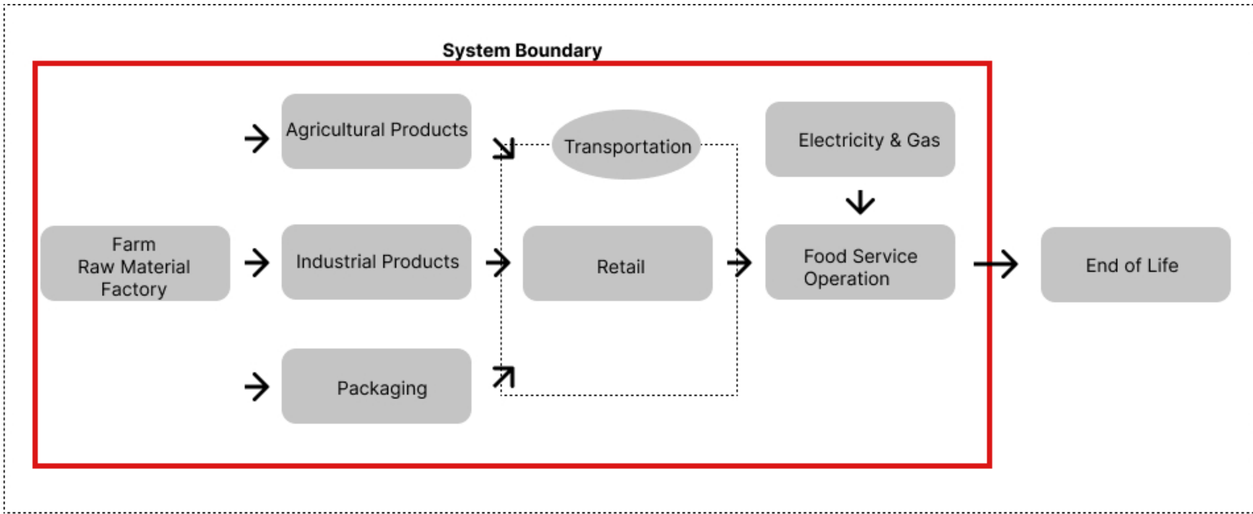

Figure 2. System boundary map. The system boundary defined for this study is farming of raw materials to foodservice operation. It begins with farming and extracting natural resources. After the agricultural products, industrial products, and packaging products are produced at the first facility, they are transported to the restaurant by the retailer. Once these products arrive at the restaurant, food is served using electricity and gas in the kitchen.

RESULTS

Among the entire system boundary, stage 1 which is producing and farming of industrial products and agricultural products showed the highest contribution of GHG emission. Stage 1 accounts for 80% of total GHG emission (Figure 3). Among stage 1, production of agricultural products such as beef, pork, chicken, octopus, and rice showed the highest GHG emission. Farming and processing of the agricultural products account for 97.86% of total stage 1 emission (Figure 4). Among the five agricultural products, production of beef is the main hotspot of GHG emissions. 84.89% of GHG emission from five agricultural products is from beef production (Figure 5). Production of beef accounts for 66.61% of the entire system GHG emissions. The emission factor of the restaurant operation is 0.45 Kg of CO_2 per USD.

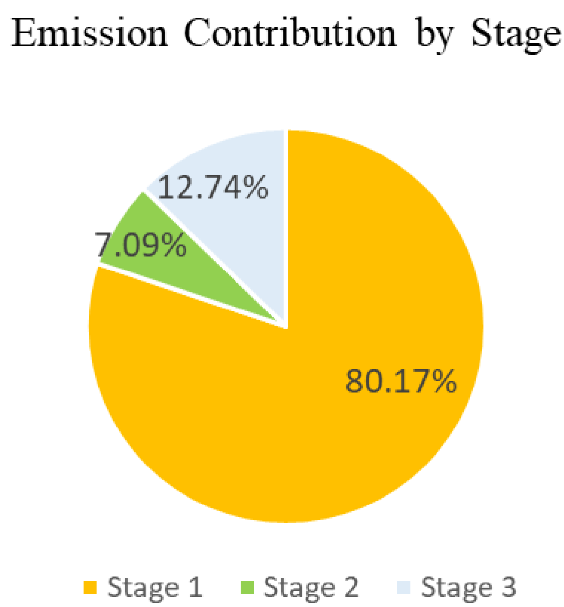

Figure 3. Emission contribution by defined stage. Stage 1, which is farming and producing of material, contributes 80.17% of the entire GHG emissions. Stage 2, which is transportation from the production facility to retailers and arrival at the restaurant, contributes 7.09%. Stage 3, which is cooking and serving at the restaurant, contributes 12.74%.

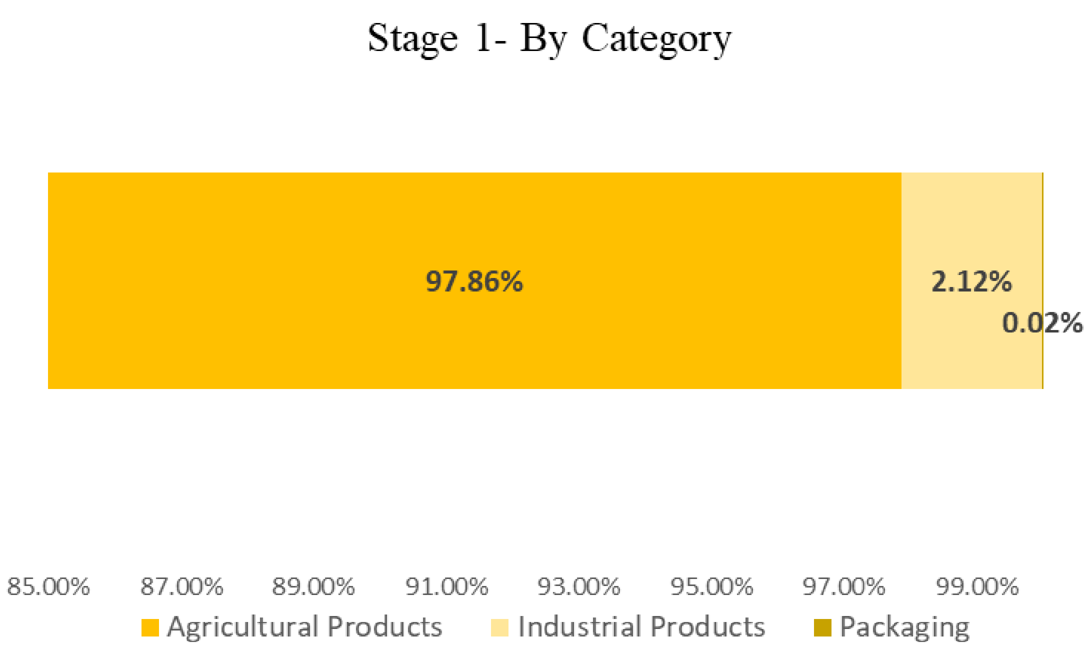

Figure 4. GHG emissions contribution in stage 1. In Stage 1, agricultural products contributed 97.86% of the stage 1 GHG emissions. Industrial products and packaging production account for 2.14% of the stage 1 GHG emissions.

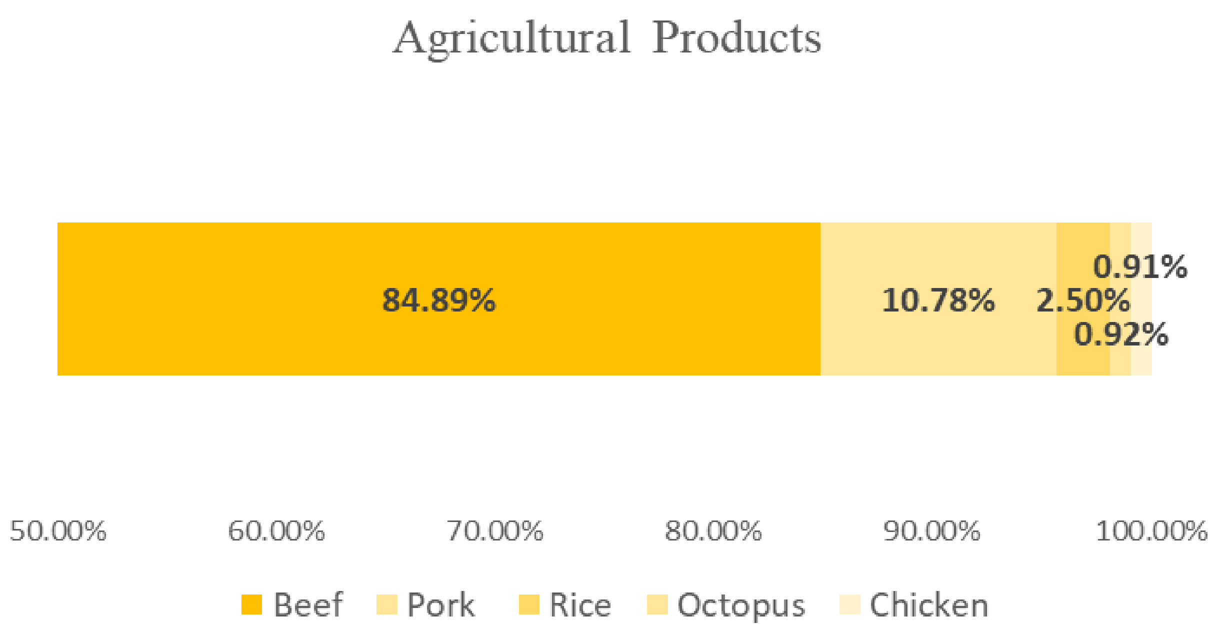

Figure 5. GHG emissions contribution in Agricultural Products. Producing beef contributes 84.89% of the GHG emissions of agricultural products. The rest of the agricultural products(pork, rice, octopus, chicken) accounts for 15.11% of agricultural products' GHG emissions in total.

DISCUSSION

This study examines the environmental impact of the entire food service operation especially focusing on GHG emissions. I found that production of beef for the restaurant operation is the heaviest emitter when compared to the other materials. Producing beef accounted for 66.61% of the entire system boundary of this study. Among the three stages, stage 1 (natural resource extraction and production of material for the restaurant) contributed 80.17% of GHG emissions. Stage 2 and stage 3, which are the transportation of materials and service operations, accounted for 7.09% and 12.74% each. During stage 1, the production of agricultural products such as meat and vegetables accounted for 97.86% of the GHG emissions. The agricultural product category includes raising and producing pork, beef, chicken, octopus, and rice.

Among the entire system boundary of this study, raising cows and producing beef is the hotspot of GHG emissions. The contribution of beef production to the total GHG emissions is around 67% of the entire system boundary. To decrease the GHG emissions of the food service operation, there can be three solutions. The first is to use beef from carbon-neutral farms. One of the carbon-neutral beef farming practices in Brazil involves planting eucalyptus trees in the same area of cattle grazing which turns a featureless grassland into land with trees (Pereira et al. 2019). The second is using the alternative meat that is recently developed. Last can be the implementation of plant-based menus instead of beef-based menus.

Transportation of materials from their origin to the restaurant takes about 8% of the entire system boundary of this study. The materials are transported by oceanic transportation or trucking and trucking is showing about 7% of the entire GHG emission of the system. Most of the materials which are from other states such as Iowa, Georgia, and Nebraska in the US are transported by trucking. Some of the materials are transported via oceanic transportation from Korea, Japan, and Mexico. To decrease the GHG emission caused by the transportation stage, MBR can change the suppliers to the local which can decrease the transportation route. But there's another research result that argues dietary shift is more effective in lowering the average food-related carbon footprint rather than buying local foods (Weber and Matthews 2008). I would suggest that changing suppliers toward carbon-neutral farming might be a better solution.

GHG emissions from the food service operational stage (cooking and packaging) contribute 13.5% of the entire system. Most significant GHG emissions are caused by gas usage at around 10.5% of the entire system. One potential explanation for this is because MBR is mainly focusing on soup-based cuisine. For the soup base, they boil bone and meat for more than 10 hours which requires a huge amount of energy. They have three potential solutions for reducing energy consumption. The first is electrifying the kitchen. Induction cooking has higher energy efficiency than traditional gas stove cooking. With the induction cooking technology, up to 90% of the energy is transferred to the food. But gas stoves only transfer 40% of energy to the food (Sweeney et al. n.d.). The second is changing their cooking tool to an electric pressure cooker which can decrease the time of boiling. The energy consumption of an eclectic rice cooker is energy efficient among the traditional cooking methods (Das et al. 2006). The last is the installation of solar panels on the roof. With the generated solar energy, they can substitute their electricity usage from the supplier.

Limitations and Future Directions

This study analyzed the GHG emission in farming and the production of materials. Emission factors were collected from former LCA studies or governmental information not directly from their suppliers. MBR is using beef meat from Iowa and the emission factor was calculated based on USA farms (Asem-Hiablie et al. 2019). The pork supply chain of MBR is from Mexico, but the study is conducted in Australia(Wiedemann et al. 2016). This is the same for chicken. MBR is using chicken from Nebraska but the LCA study for emission factors was conducted in Australia (Bengtsson and Seddon 2013). LCA studies for emission factors of beer and octopus were conducted in the UK, but both are imported from Korea (Amienyo and Azapagic 2016, Clune et al. 2017).

Another limitation of this study is the assumption of some material usage, emission factors, and transportation routes. Beef and soda consumption data were not found. So their usage was based on the interview and estimation of the manager. Emission factors regarding all of the sauces that are used for cooking at MBR couldn't be collected nor found from existing LCA studies. So their value was estimated as 20% of the emission factor of beer and soda. The data on exact transportation routes was not collected. So rough calculation was used for the transportation route of materials. Data regarding waste management was not available from the existing LCA studies that used similar study contexts with this study. . This caused the exclusion of the end-of-life stage for this LCA study.

LCA case studies for restaurants are not well documented. So, the results of this study are not comparable with other restaurants. This study can help to fill the gap in LCA study on foodservice operation. LCA studies that include the end-of-life stage would be of significant future benefit.

Broader Implications and Conclusion

This study presents an overview of the GHG emission from the operation of a Korean restaurant in the USA. Results showed that the most dominating GHG emission results in producing beef meat. The GHG emission also came from the transportation of products and operational energy consumption. With the sources of the GHG emission identified, several ways to reduce the GHG emission were outlined.

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