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Life cycle assessment of supermarket food waste

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ABSTRACT

Retail is an important actor regarding waste throughout the entire food supply chain. Although it produces lower amounts of waste compared to other steps in the food value chain, such as households and agriculture, it has a significant influence on the supply chain, including both suppliers in the upstream processes and consumers in the downstream. The research presented in this contribution analyses the impacts of food waste at a supermarket in Sweden. In addition to shedding light on which waste fractions have the largest environmental impacts and what part of the waste life cycle is responsible for the majority of the impacts, the results provide information to support development of strategies and actions to reduce of the supermarket's environmental footprint. Therefore, the food waste was categorised and quantified over the period of one year, the environmental impacts of waste that were generated regularly and in large amounts were assessed, and alternative waste management practices were suggested. The research revealed the importance of not only measuring the food waste in terms of mass, but also in terms of environmental impacts and economic costs. The results show that meat and bread waste contributes the most to the environmental footprint of the supermarket. Since bread is a large fraction of the food waste for many Swedish supermarkets, this is a key item for actions aimed at reducing the environmental footprint of supermarkets. Separation of waste packaging from its food content at the source and the use of bread as animal feed were investigated as alternative waste treatment routes and the results show that both have the potential to lead to a reduction in the carbon footprint of the supermarket.

1. Introduction

Food, during its life cycle, contributes to current global environmental challenges such as climate change, eutrophication, terrestrial and aquatic acidification, depletion of the stratospheric ozone layer, depletion of natural resources and loss of biodiversity (Garnett, 2013; Hertwich and Peters, 2009; Pretty et al., 2005). Furthermore, the global food demand is projected to increase by 70% by 2050 (FAO, 2009), which may well increase the environmental impact on the planet.

These issues are aggravated by the wastage of one third of all food produced for human consumption (Gustavsson et al., 2011), and raises ethical concerns since 795 million people suffer from undernourishment (FAO et al., 2015). According to the Food and Agricultural Organisation of the United Nations (FAO, 2013), the global food waste in 2007 was estimated to be 1.6 Gtonnes of primary product equivalents and the corresponding edible part was estimated as 1.3 Gtonnes.

Reduction of food waste is, therefore, important for food security and for reducing unnecessary economic costs. It will also reduce environmental impacts, and is less controversial than alternatives such as the reduction in consumption of some products like meat and dairy (Beretta et al., 2013; Gruber et al., 2015; Scholz et al., 2015).

Even though retail has lower amounts of food waste compared to other steps in the food value chain, (FAO, 2013; Naturvårdsverket, 2013), it has a significant influence on food waste generated throughout the supply chain. The European Commission (2013) reported that retailers have increased their bargaining power over other actors in the supply chain. Retailers also influence – and are influenced by – consumers that are downstream in the supply chain. For example, there is a large amount of waste in primary production due to the strict quality standards of consumers and retailers that define product classes. Food products that are classified as lower quality can yield lower profits, and it is therefore often not financially viable to harvest the product, even though it could be sold in supermarkets. For instance, each year 15% of lettuce grown in Sweden is not harvested (Livsmedelsverket, 2015).

Retailers are located towards the end of the supply chain, and hence a large environmental impact has already been generated

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from transportation, packaging and other processes before the food reaches the supermarkets. It also concentrates large quantities of waste at a few physical locations, which facilitates collection of the waste for further treatment as well as data of the waste fractions and quantities. Thus, supermarkets are potentially good targets to investigate food waste and subsequently implement measures for waste prevention. This would reduce the environmental impacts of the waste as well as economic losses suffered by the supermarkets (Scholz et al., 2015).

Statistics on the amount of food waste generated in the Swedish retail sector varies substantially depending on the source of the data. This is also true for the fraction of this waste that is avoidable, defined as "food that could have been eaten provided that it has been handled correctly and eaten by its use-by date" (Naturvårdsverket, 2013). For example, Naturvårdsverket (2013) reported that 70,000 t of food waste was generated by food retailers during 2012, of which 91% was avoidable. In a more recent report (Naturvårdsverket, 2016) they recalculate this figure to be 45,000 t. The reason for this large discrepancy is not clear, but may be due to differences in methods to obtain these figures. Of interest is that, using the newer method to calculate the food waste, there was a reduction from 45000 t in 2012–30000 t in 2014. Surprisingly, only 36% of this 30000 t was avoidable (compared to the value of 91% determined for 2012). Irrespective of this, there is substantial food waste in the Swedish retail sector.

This study analyses the food waste at a supermarket in Sweden in terms of product type, mass, environmental impacts and economic costs. The supermarket is located in the city of Borås, and has a sales area of approximately 410 m^2. It is therefore a typical mid-size urban supermarket (Gómez-Suárez and Martínez-Ruiz, 2016). The results presented here are therefore expected to be relevant for many Swedish supermarkets, and perhaps even for retailers in other developed countries. In addition, the information obtained in this study can be used to support the development of strategies and actions aimed to reduce supermarket food waste and to identify alternative waste treatment routes that reduce the supermarket's environmental footprint.

This study is divided into three parts:

(i) The categorisation and quantification of food waste in the supermarket over a one year period.
(ii) The results from the waste categorisation and quantification revealed which waste fractions were large and generated often. The environmental impacts of these waste fractions were assessed.
(iii) The results from the waste categorisation and quantification together with the life cycle assessment (LCA) supported the design of alternative waste treatment routes. The change in the environmental footprint for each alternative was quantified.

2. Material and methods

2.1. Waste categorisation and quantification

The type and amount of food waste at the supermarket was gathered from October 2014 to September 2015. Products that were considered unsellable due to defects or that have expired shelf-life were scanned by a bar code reader and the data was saved in the supermarket's database. Products that were sold without a bar code, such as fruits and vegetables, were weighed, and the mass of the waste was entered manually into the database. After the data collection, the food products were categorized. This study does not differentiate between avoidable and unavoidable food waste. It is assumed that the waste was edible at or before the time that it was disposed of, or that an excessive amount of products was ordered and that this led to waste.

The economic analysis is limited to the costs incurred by the supermarket and it includes the purchase costs of the wasted products and the disposal costs (including fetching the waste from the supermarket). Other costs borne by the supermarket, e.g., salaries, were not included. This analysis was incorporated as a secondary goal in this study since economic losses are important for motivating change in the retail sector.

Pre-supermarket waste, which is waste that is rejected upon delivery, is not included in this study since it was not recorded in the supermarket's database. Pre-supermarket waste consists of items that do not satisfy the quality requirements of the supermarket (Eriksson et al., 2012). According to Eriksson (2015) pre-supermarket waste can represent significant quantities of waste, particularly for fruits and vegetables, where it can correspond to three times the amount of waste in the supermarket.

2.2. LCA of the supermarket food waste

Food waste fractions that were generated often (high frequency) and in large amounts were included in the LCA. The frequency of waste generation was assessed as the number of days in the year that the product was disposed of. This parameter was used to avoid waste that was generated due to a single or infrequent occurrence, such as a breakdown of equipment. Waste fractions that occur in frequent and large amounts are of more interest than those that are generated in small amounts and less often since they are statistically more meaningful (they are more likely to represent annual waste fractions and quantities over several years).

2.2.1. Goal and scope definition

Based on the criteria discussed in the previous paragraph, the waste fractions that were selected for the LCA were beef, pork, chicken, bread, strawberries, bananas, tomatoes, lettuce, potatoes, carrots, cabbage and apples. Dairy waste was not included in the main LCA due to the large variety of wasted products and the lack of available data to accurately model all impact categories.

The functional unit for this study is the waste generated by the supermarket from October 2014 to September 2015 for the selected products, which corresponds 11.4 t from the total of 22.5 t of food waste generated during that period. This is similar to that used in comparable LCAs (Scholz et al., 2015), and was used since the aim was to compare the environmental impacts of different food waste fractions generated during an entire year. Impacts per kg of food waste are presented in Section 2.2 of the Supplementary material.

2.2.2. System boundaries

Fig. 1 shows the simplified flow chart of the waste fractions that were analysed and includes some of the relevant processes used to model each product. The life cycle was modelled from the cradle to the grave. It includes processes from the agricultural production, packaging production, transportation, retail and end of life treatment. The bakery stage is also included for bread waste. The city of Borås, Sweden was the geographical reference for the retail and for the waste treatment. A global dataset that is based on the average global data was used for the agricultural production. The current waste management practice in the city is to use the food waste for anaerobic digestion. The waste treatment is explained in more detail in Section 2.3. More details of the data and assumptions made for the life cycle modelling are available in Section 2, Supplementary material.

The fruits and vegetables sold in the supermarket come from different countries and some of products even have several countries of origin. Representative countries for each waste fraction were chosen to model the transportation routes. For each waste frac-