Journal of Cleaner Production 69 (2014) 83–90

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Reusable plastic crate or recyclable cardboard box? A comparison of two delivery systems

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ARTICLE INFO

Article history:
Received 10 January 2013
Received in revised form
9 January 2014
Accepted 12 January 2014
Available online 27 January 2014

Keywords:
Packaging
Transportation
Delivery
Life cycle assessment
Corrugated cardboard
Plastic

ABSTRACT

During a product's entire life cycle the significance of packaging varies in terms of environmental impacts. From the perspective of companies which manufacture packaging or packaging has an important role in their value chain it can be a relevant issue to focus on in their efforts to improve the environmental performance of their activities. The aim of this study was to compare the life cycle environmental impacts of a real product (bread) delivery system using either reusable HPDE plastic crates or recyclable corrugated cardboard (CCB) boxes for product transportation. In this paper we focused on the delivery systems (not the delivered product) covering the manufacturing of the crates/boxes, their use, the delivery routes from bakery to retailers and waste management/recycling of the crates/boxes. As a result we concluded that the recyclable CCB box system was a more environmentally friendly option than the reusable HPDE plastic crate system in all the studied impact categories based on the defined boundaries and assumptions. Transportation played a very important role in the environmental impacts of the analysed systems. Therefore, changes, e.g. in the weights of products and their secondary packaging or the transportation distances could affect the results considerably.

1. Introduction

During a product's entire life cycle the significance of packaging varies in terms of environmental impacts. Especially with foodstuff, manufacturing of the product itself is much more resource and energy intensive than the manufacturing of its packaging (Jungbluth et al., 2000). However, from the perspective of companies which manufacture packaging or packaging has an important role in their value chain, it can be a relevant issue to focus on in their efforts to improve the environmental performance of their activities. Emissions from the production stage of packaging are not the only aspects to be considered. In delivery systems, upstream processes, transportation in the distribution network and waste management issues must also be taken into account in order to assess environmental impacts holistically.

Many industrialised countries have policy frameworks and measures aiming to minimize packaging waste and their environmental impacts (e.g. Sonneweld, 2000). The measures vary from strict regulations imposed by governments to voluntary agreements between stakeholders. According to the waste hierarchy given in the EU Waste Framework Directive (2008/98/EC), the first priority of waste management is to prevent waste from being generated. Also the European Parliament and Council Directive on packaging and packaging waste (94/62/EC, amended by the Directive 2004/12/EC) contains provisions on the prevention of packaging waste, on the reuse of packaging and on the recovery and recycling of packaging waste. Reuse of products is undoubtedly a good measure for preventing waste since it can lengthen the lifetime of a product significantly. However, when looking at the overall environmental impacts of the product system where the reusable product is included, the picture is more complex due to e.g. the transportation and washing needed in order to enable the product reuse. This emphasizes the need for comprehensive environmental assessments of product systems in order to support decision making when choosing between different types of packaging materials and products.

At present, packaging is a necessary part of delivery systems. The basic packaging functions are transportation, storage and distribution (Oki and Sasaki, 2000). In general, the functions of packaging materials, such as prevention of contamination, protection

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0959-6526/$ – see front matter © 2014 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.jclepro.2014.01.045

against damages, preservation of contents and communications to the customer, are many and varied in extent and complexity (e.g., Oki and Sasaki, 2000; Pasquilo et al., 2011). In our study we focused on storage, loading and transportation functions. The transport of goods demands particular container properties related to e.g. shape, weight, hygiene, handling and labelling (Stiftung Initiative Mehrweg, 2009). Transportation itself can be a very important factor in climate change impacts caused over the life cycles of packaging (e.g. Andersson and Ohlsson, 1999; Sim et al., 2007; Pretty et al., 2005; Meisterling et al., 2009). The importance of transport modelling in LCA has been well known for long (Jørgensen et al., 1996). According to Jørgensen et al. (1996), transport contributes to 5–15% of the major environmental impacts of a life cycle of a product. According to Madival et al. (2009), transport may contribute significantly to the environmental impacts of agricultural products and Gunady et al. (2012) emphasise especially the effects of a long distance transport.

In recent decades, there has been an ongoing trend to find new materials based on biomass or renewable resources to replace non-renewable materials, e.g. petroleum-based plastics (e.g. Madival et al., 2009). Several current policies (e.g. "Thematic Strategy on the Sustainable Use of Natural Resources COM/2005/670, An EU Strategy for Biofuels" COM/2006/34, A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy COM/2011/21), which aim to achieve a more resource-efficient economy, support the increased use of materials made from renewable resources. Products made from renewable materials are not automatically a better choice over ones made from non-renewable materials, since the whole supply chain from extraction to end-of-life must be considered. There can be aspects, e.g. reusing or recycling of packaging, which could change the ranking.

Many comparison studies of packaging systems have been accomplished (e.g. Ross and Evans, 2003; Lee and Xu, 2004; Singh et al., 2006; Raugei et al., 2009). In all of them reusable plastic containers proved to be a better choice compared to single-use packaging. This bears out the general conception that reuse is always better than recycling. But is it true in every case?

In our study we compared the life cycle environmental impacts of a *real life* delivery system using HDPE plastic crates or CCB boxes for transportation of the delivery product. We assessed the impacts of two delivery systems, one using a crate made of non-renewable plastic and a box made of renewable CCB. Both materials have advantages and disadvantages in terms of environmental impacts. Plastic crates are durable and washable, hence they can be reused several hundred times (in our study approximately 700 times) before finally being recovered as material for new plastic products or as energy. CCB boxes can be designed to be strong but light, and although they can only be used once, they can be recovered and used in the production of new fibre products or as energy.

Levi et al. (2011) compared plastic containers and corrugated boxes to each other in Italian fruit distribution. They concluded that emissions from the manufacturing of corrugated box were greater than those from manufacturing plastic crates and the importance of transportation was identified in the environmental impacts of the distribution systems. The study of Stiftung Initiative Mehrweg (2009) presents the results of a comparison of fruit delivery systems in some European countries and Singh et al. (2006) in Northern American market finding the plastic container system better than the CCB system. However, these studies cannot be compared to our study as such due to several differences in the modelling assumptions. The greatest differences existed in e.g. the material composition of the crates/boxes, their weights, the number of circulations and transportation parameters. Additionally, end-of-life phases deviated from each other for both plastic crates and CCB boxes.

The scope of the comparison is not the use of secondary packaging needed for the delivery system, but the delivery system of packaged bread using CBB and HDPE plastic crates. The aim was to compare the life cycle environmental impacts of a real delivery system using either reusable HDPE plastic crates or recyclable CCB boxes for product transportation. The delivered product was toast bread which is a light weighted packed daily foodstuff delivered to the whole Finland. The results do not include the processes related to bread baking and its upstream, because the delivered product is not in the focus of this study. The weight of bread is, however, taken account in the impacts of transportation. The study was implemented in cooperation with the leading bakery company in Finland (VAASAN Oy) and with a global manufacturer of biomaterials, paper, packaging and wood products (Stora Enso Oyj). Both provided data and valuable insights from a business perspective for the study. A critical review of the study was conducted by the Swedish Environmental Research Institute (IVL).

2. Materials and methods

2.1. Life cycle assessment and data sources

In order to achieve more sustainable production patterns, the environmental implications of the whole supply chain of products (both goods and services), their use, and waste management (ILCD, 2010) must be considered. Life cycle assessment (LCA) studies thereby help to avoid resolving one environmental problem while creating others, avoiding so called "shifting of burdens". Life cycle assessment (LCA) is a method for integrating the environmental impacts of a studied product or a service over the whole value chain. It is an internationally standardized method (ISO 14040, 14044) with comprehensive guidelines (ILCD, 2010). In full LCA all processes and flows are followed from cradle-to-grave (i.e. from resource extraction to waste disposal) taking into account all relevant environmental impact categories.

The goal of the study was to compare the life cycle environmental impacts of two different product systems for bread delivery from the bakery to consumers. The main difference in the systems was the type of material used for the delivery crates, either plastic or CCB, which generated differences in, among others, manufacturing and transportation (Fig. 1). The product systems (referred to as plastic crate system and CCB box system) included the life cycles of manufacturing of the crates/boxes from virgin materials and the delivery system of bread. The study tried to establish which container material would be more favourable from an environmental perspective in this specific distribution system.

The weight of one plastic crate is 1.450 g with inside dimensions of 560 × 360 × 125 mm. It is made of high-density polyethylene (HDPE). The CCB box weighs 190 g and its dimensions are 540 × 330 × 110 mm. The bread delivered is toast bread. The weight of an average loaf of bread is 340 g (2.720 g in one crate/box). The weight of one plastic bag used for the bread packaging is 2 g (16 g in one crate/box). The different dimensions of a crate/box indicate slightly different capacities. However, all the crates/boxes hold the same load, 8 loaves of bread, therefore they perform the same function in the studied systems.

Collected inventory data consisted of primary data from the participating companies, e.g. data related to the manufacturing of CCB boxes, transportation distances and modes and the washing process for crates. The washing of crates, but not the consumption of tap water (as a resource), was included in our assessment. The washing process also requires energy for heating the water and for the washing process, impacts of which are included in the study. The washing mainly removes dust from the crates and the detergents used for washing do not include phosphorus. Generic data