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Accounting the impacts of waste product in package design

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Abstract

In Life Cycle Assessment (LCA), packaging has been considered environmentally damaging due to its material use and issues with disposal at the end of it life. Consumers' relationship with packaging is short-lived with the focus of desire being the product contained in the package, and once received the packaging is no longer required and is in certain circumstances a waste management issue. Packaging designers however have long since known the function of the packaging is to deliver the product to the consumer is such a way that the product is protected and possibly enhanced. However, to date packaging design tools which evaluate the environmental performance of packaging design have ignored the product delivery function, or at least considered it to be equivalent in all cases. The packaging quick evaluation tool (PIQET) is expanding its evaluation to incorporate product production impacts, product loss and the disposal of product loss into the life cycle of packaging. As a screening tool, it is not practical to include detailed LCAs of all products, however using environmentally extended input output data to ratio product to packaging impact, it is possible to provide sufficient guidance to the packaging designer as to the benefits or high quality packaging design. This paper presents a case study application of this approach as a proof of concept to its value in the environmental assessment of packaging design.

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Keywords: Packaging,; LCA, Food and Beverage

1. Introduction

In Life Cycle Assessment (LCA), packaging has been considered environmentally damaging due to its material use and issues with disposal at the end of it life. The earliest LCA studies were undertaken on packaging, with Coca Cola considered to have undertaken the first LCA in 1969(Hunt and Franklin 1996). Consumers' relationship with packaging is short-lived with the focus of desire being the product contained in the package, and once received the packaging is no longer required. Consumers are almost unaware of the functioning of packaging, but once it is separated from the product the packaging is seen as waste with its original function quickly forgotten.

The requirements of any packaging system consist of those relating to the marketing, technical performance and legal requirements (Stewart 2012). However to date packaging design tools such as PIQET (Sustainable Packaging Alliance 2014), Compass (Sustainable Packaging Coalition 2012)and PackageSmart (Earthshift 2014) have not taken the impacts of product manufacture or product loss into account.

This paper outlines a method to expand the PIQET tool to include product impacts in the assessment of packaging and to allow the product, packaging and use to all be evaluated in the one framework.

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2. Methodology

Packaging LCA studies typically have the packaging function as the functional unit. For example the functional unit for a display packaging LCA recently undertaken by Franklin associates was “1,000 tons of produce delivered to retail stores in North America (US or Canada)” (Franklin Associates 2013). So the initial decision when incorporating product into the packaging LCA is how to structure the functional unit and what to include in the system boundary.

Two options are examined in this paper with option 1 being to simply expand the system being considered from the perspective of the packaging. In a comparative LCA study, which all design studies essentially are, the boundary for the assessment should take into account all the factors that have a material influence on the environmental impacts of the system being studied. In the case of packaging where different designs lead to changes in product loss or product wastage, then this loss or wastage should be included in the study. Where the packaging design has no effect on the product loss or wastage then the product can be excluded from the study as it will be common to all alternatives.

Fig. 1 shows an outline of the packaging life cycle and identifies specifically the product supply chain within this. The raw material and manufacturing impacts of the product are still excluded from this packaging assessment however the raw material and manifesting impacts of products that are wasted through the supply chain can be included as a direct impact of the packaging performance. Likewise the disposal impacts of wasted product can also be included in the packaging life cycle. It would also be possible to only include the difference in product loss between packaging options being compared. The benefit of this approach is that the impacts of the packaging can still be discerned from the impacts of the product. If the product manufacture and disposal is included in the assessment of packaging then the contribution of packaging may be small and design improvements in that packaging may appear to be negligible. However negligible results are only negligible relative to other contributions and in the case of packaging if there are millions of units of packaging being produced then small savings in the packaging could lead to large savings in environmental impacts even if the product impacts are much larger than these.

Option 2 for including the product in the packaging assessment is to focus on the full product life cycle with their product itself being the functional unit as is shown in Fig. 2. This has distinct advantages in terms of keeping the relative environmental priorities between product and package clear in the designers mind. There are many instances where an increase in packaging can lead to a decrease in product wastage.

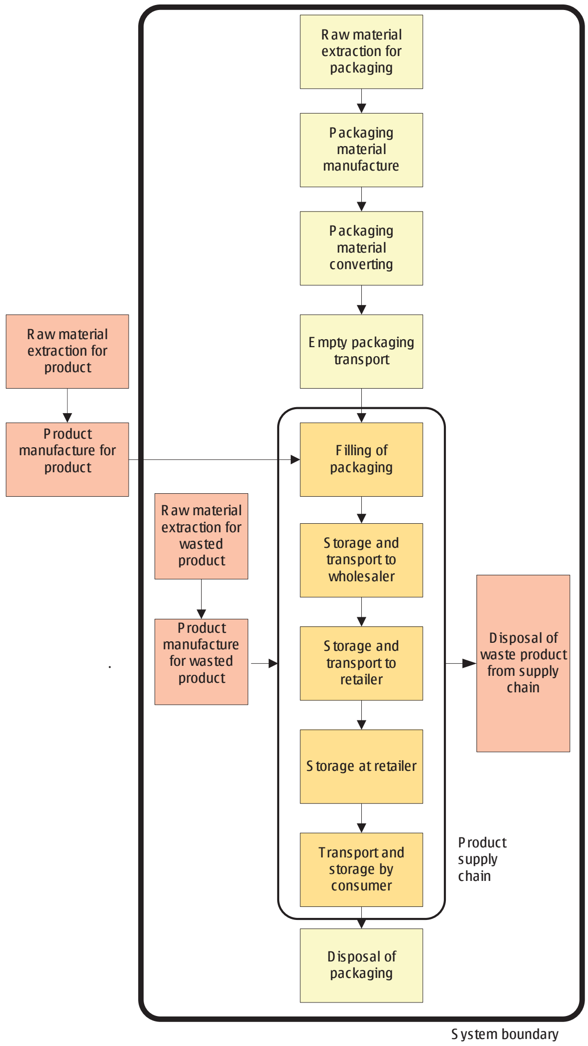

Fig. 1. Packaging system including product loss impacts.

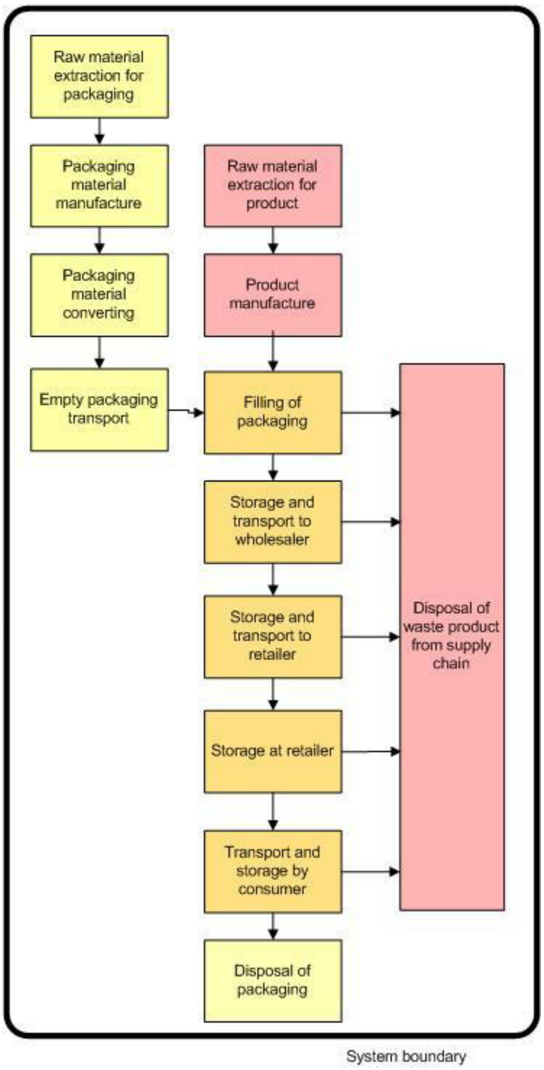

Fig. 2. Product system including packaging impact and product loss.

3. Data requirements

Finding appropriate data is always a challenge in any LCA and for a generalized tool this is compounded by the breadth of possible systems which could be included. However the purpose of PIQET and other packaging assessment tools is to provide an early assessment tool for screening environmental impacts of packaging design options.

For option 1 mentioned above where only relative impacts of lost product are being taken into account it would be possible to use environment and environmentally extended input output data for the product impacts. Input output data refers to national accounts which describe how sectors of the economy interact with each other. By using this, data supply chains can be described using economic flows and environmental attributes can be added to each sector so that the cumulative environmental impacts of a sector can be calculated. This is in contract to tranditional "unit process"LCA which calculate the life cycle impact by examining each unit process from raw materials up to manufacturing and to disposal with physical flows of energy material be in accounted. EEIO typically produces a more complete however the result than unit process LCA but the results is highly generalized to sectors of the economy rather than specific products or technologies.

While many countries have input output tables, the quality and disaggregation of these tables vary substantially. The US input output table is one of the most disaggregated containing over 400 sectors. For this reason it is a good candidate for a generalized input output database that could provide relative impacts between product and its packaging systems.

For option 2 more traditional LCA approach would be required where the raw material inputs are identified and each step in the supply chain is modelled with energy and material data. This however requires significant quantities of data, particularly from agricultural production systems. There have been substantial improvements in the availability of food and agriculture data with improvements in version 3 of the ecoinvent (Weidema, Bauer et al. 2012), Agri-footprint database(Blonk Consultants 2014), the AusAgLCI database (Grant, Cruypenninck et al. 2014), LCA commons(United States Department of Agriculture 2014) in the United States, and the impending release of the data from the World Food Database (Benoga and Peano 2013).

4. Results

Only option 1 has been tested to date to include the impact of product waste into the packing evaluation. Using an environmentally extended US Input Output model published by Suh (2004)the impacts of the Frozen foods sector was analyzed. A total of 165 sectors contributed to this sector. These were further grouped into those from the food, packaging (paper, plastics glass bottles etc) and transport sectors amongst others as shown in Table 1. In all categories the product impacts are dominant and in some cases constitute almost all the impact such as in land use and eutrophication potential. In other impact categories packaging can become significant from 4% to 10%. The variations between contribution from different sectors means that a fixed ratio of product to packaging impact would not be suitable. A second comparison of the impacts of breakfast cereal production compared to packaging shows similar results in Table 2 however the packaging impacts are larger than for frozen food products. This is due to the meat in frozen food products having substantially higher impacts compared to cereal grain which is the dominant ingredient of breakfast cereal.

Table 1. Spread of impacts for frozen foods from US inputs output data.

An example of a column heading	Product	Packaging	Transport	Other
Global Warming	79%	4%	2%	15%
Ozone depletion	89%	6%	0%	4%
Eutrophication potential	99%	0%	0%	0%
Particulate matter	72%	4%	14%	11%
POCP	86%	3%	5%	5%
abiotic resource depletion	49%	7%	5%	39%
Embodied energy	60%	6%	6%	27%
Human toxicity	47%	10%	1%	42%
Land Use	99%	0%	0%	0%
Water footprint	92%	1%	0%	6%

Source:(Suh 2004)

Table 2. Spread of impacts for breakfast cereals from US inputs output data.

An example of a column heading	Product	Packaging	Transport	Other
Global Warming	75%	10%	2%	12%
Ozone depletion	81%	17%	0%	2%
Eutrophication potential	93%	1%	0%	7%
Particulate matter	65%	9%	17%	10%
POCP	84%	8%	4%	4%
abiotic resource depletion	49%	15%	4%	32%
Embodied energy	62%	14%	5%	20%
Human toxicity	54%	19%	1%	26%
Land Use	93%	0%	0%	6%
Water footprint	85%	2%	0%	12%

Source:(Suh 2004)

However if a packaging system was losing 10% of the product through the supply chain, it would be possible to estimate the relative impact of this compared to the packaging manufacturing impacts. Fig. 3 shows the relative impact of 10% product loss is larger than the impact of packaging in 7 of the 10 indicators and is significant in the other 3 indicators. These results provide support to the increasing importance being given food waste globally (FAO ref) and the 10% food waste is on the lower end of estimates. The data in Fig 3 does not include the impacts of disposing of food waste, which, if disposed to landfill, can cause considerable impacts from degradation of organic material to methane which is a potent greenhouse gas.

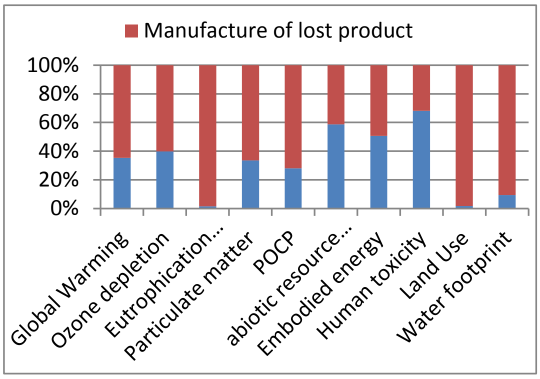

Fig. 3. Comparison of impact of Frozen food product packaging system and manufacturing impact of 10% product loss.

5. Conclusions

This paper has shown the importance of including food production impacts in packaging studies. Even at modest waste levels, the product loss can quickly swamp the impacts of the package itself. What remains to be determined is the best way to include this data within the packaging system? The use of relative impacts from input output data gives a good way to characterize many products across different sectors, however the results will not be specific to actual manufacturers and cannot be easily customized to manufacturers' specific processes. Further investigations of a more product focused analysis of packaging is required to establish if sufficient data can be found to model product supply chains in a streamlined manner for inclusion in packaging and product design tools.

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