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Sustainable Packaging

Background

Sustainable packaging (also referred to as eco-friendly, environmentally-friendly and green packaging) is frequently discussed in the popular and trade media and is something that almost all major food companies have publicly committed to. However, defining what sustainable packaging actually is presents a challenge and there is no single universally-accepted definition.

Sustainability has been an often-mentioned goal of businesses, not-for-profits and governments over the past decade, yet measuring the degree to which an organisation is sustainable or pursuing sustainable growth can be difficult. In its simplest sense, sustainable means "to maintain or keep going continuously," and it has been used in connection with forest management for over a century (Robertson, 2009). According to the U.S. Environmental Protection Agency, "sustainability, or sustainable development, is the ability to achieve continuing economic prosperity while protecting the natural systems of the planet and providing a high quality of life for its people." Implicit in this definition is the reality that consumption of resources must match their rate of renewal, and the use of nonrenewable resources, including metals, and plastics from fossil carbon sources such as crude oil and natural gas, is unsustainable.

Since the concept of sustainable development was first defined by the Brundtland Commission in 1987, sustainable development has emerged as the guiding principle for long-term global development. It is based on the triple bottom line or 'three-pillar' interpretation of sustainability that incorporates three dimensions of performance: social, environmental and financial, popularly referred to as the three Ps: people, planet and profits (Robertson, 2013). This approach aims to achieve social equity, environmental protection and economic prosperity in a balanced manner.

In 2005, the U.S.-based Sustainable Packaging Coalition defined sustainable packaging by listing eight criteria that blended broad sustainability objectives with business considerations and strategies to address the environmental concerns related to the life cycle of packaging. One of the Coalition's criteria is that sustainable packaging is sourced, manufactured, transported, and recycled using renewable energy, which means that there is no sustainable packaging on the market today. While no one solution meets every criterion for sustainability, the single most important sustainability attribute is that the packaging must succeed in protecting foods and delivering them in good condition, together with relevant information, cheaply and conveniently, to consumers. The current and traditional linear extract-produce-use-dump material and energy flow model of the modern economic system is unsustainable and causes serious environmental harm. A circular economy provides the economic system with an alternative flow model and is now being actively promoted in several parts of the world.

Over and Under Packaging

For any packaging system there will be a specific amount of a particular packaging material that represents the optimum use of that material in that system; use too little and the under-packaging will result in negative environmental impacts (e.g., from spoilt food) while overpackaging will also increase the environmental impacts by using unnecessary packaging material. Optimum amounts of different materials will have different environmental impacts such as greenhouse gas (GHG) emissions, air, land or water pollution, minerals depletion, etc., and these impacts can occur at different stages of the life cycle (Russell, 2014).

Packaging designers usually seek the optimum combination of package design and materials to minimise the total cost and environmental impacts of packaging, transportation and losses, while ensuring food safety and consumer acceptability. The concept of optimal package design is illustrated in Figure 1, and recent innovations in materials and designs have allowed the optimal amount of packaging required to decrease over time.

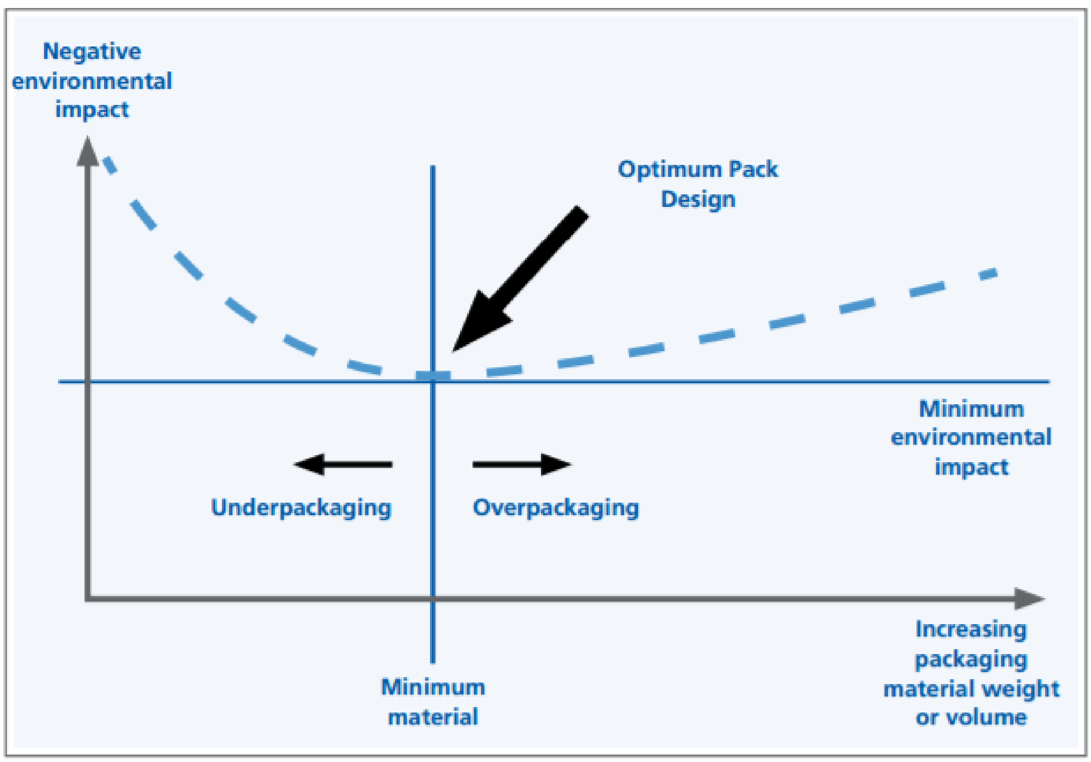

Figure 1: The environmental consequences of product losses caused by excessive packaging reduction are far greater than guaranteeing adequate protection through an incremental excess of packaging.

Figure 1 shows that while an increase in packaging material through overpackaging increases the negative environmental impacts, more importantly, when foods are underpackaged, the environmental burden increases more rapidly due to the higher environmental impacts caused by the combination of the wasted food and the package. Although less packaging material is used in underpackaging and is less expensive compared to overpackaging, the environmental impacts are higher when the package does not protect the food inside in a satisfactory manner (Hellström & Olsson, 2017).

There is a similar optimum in terms of the mechanical recycling of packaging materials. Collecting and recycling used packaging helps to preserve the financial and energy inputs that went into creating the material and to reduce environmental impacts by not requiring new packaging material to be created, but only up to the point where collection, sorting, cleaning and reprocessing is cheaper, requires less energy and causes fewer unwanted emissions than the production of the virgin packaging material. The more dispersed or contaminated packaging material becomes, the less sustainable its mechanical recycling will be (Pilz *et al*., 2010). Two interlinked aspects of sustainability should be considered when choosing optimal waste management options: which recovery option provides the highest environmental benefit, and do the benefits for society (monetised environmental benefits and economic benefits) justify the recovery costs?

While packaging cannot be separated from the food chain, consumers and legislators are generally only exposed to two links in the chain: retailing and waste collection. As a result of this limited view, it is unsurprising that consumers question the amount of packaging with which they have to deal, seeing it as a drain on resources and wondering why it is not all recycled. The danger of this perception is that it encourages a focus on design for recycling to the exclusion of design for sustainability, shifting environmental impacts to new points in the value chain rather than reducing overall life cycle impacts. The whole value chain has a responsibility to explain that sustainability is not synonymous with recycling, recyclability, recycled content, biodegradability and other popular buzz words, but that it is the overall resource efficiency of the supply chain that should be the main priority (Russell, 2014).

Robertson (1990) suggested that assessing the sustainable impact of packaging can be meaningful only if one is cognisant of the different functions of packaging and the effects they have on sustainability. Sustainability efforts aimed at reducing the environmental impacts of packaging often overlook the primary role of food packaging: protecting and preserving both perishable and shelf stable foods. Environmental concerns about packaging tend to focus on the direct environmental impacts of packaging material production and packaging end-of-life treatment, despite indications that efforts to reduce indirect impacts of food waste often far outweigh efforts to reduce direct impacts (Silvenius *et al*., 2013; Russell, 2014; Wikström *et al*., 2018).

Are Biobased Plastics Sustainable?

The term "sustainable" is often assumed to be synonymous with "renewable" but plastics made from renewable biobased resources are not necessarily eco-efficient. Given the lack of agreement on what sustainable packaging is, one must turn to life cycle analyses and assess the environmental impacts. In a comprehensive analysis, Weiss *et al.* (2012) compared the environmental impacts of biobased materials in a meta-analysis of 44 life cycle analysis studies. They found that biobased materials saved primary energy and GHG emissions but may have increased eutrophication and stratospheric ozone depletion. Most impacts were caused by the application of fertilisers and pesticides during industrial biomass cultivation. Loss of biodiversity, soil carbon depletion, soil erosion, deforestation, as well as GHG emissions from indirect land-use change, were not quantified in the life cycle analyses.

The main drivers for using biodegradable plastics are landfill capacity, pressure from retailers, consumer demand and legislation based on concern over fossil-fuel dependence and GHG emissions. Key considerations are the amount of non-renewable energy used in their manufacture and potential land-use implications. To realise the benefits of biodegradable plastics, municipal composting facilities must be available but few cities have such facilities or the capacity to collect green waste separately; this is a major drawback to their wider use. Although ultimate biodegradability in the natural environment is important, biobased plastics are required to biodegrade in a controlled way as their service life may be a year or more before environmental degradation begins. The biggest benefit of composting is avoidance of methane production in landfills from anaerobic biodegradation. It has been suggested that biobased but not biodegradable plastics is the way forward (Robertson, 2014). The global bioplastics production capacity was 2.05 million tonnes in 2017, of which 57% was biobased but not biodegradable, with biobased polyethylene terephthalate (bioPET) being the leading plastic.

Environmental Impacts of Packaging

Continuous developments in materials science and packaging engineering have allowed companies to offer packaging materials with improved performance and reduced weight, with net positive economic and environmental benefits. For example, the weight of a 500 mL PET water bottle has been reduced from 28 g in 1985 to 8 g today. Packaging reduction remains a potential strategy for overall impact reduction, provided it does not negatively impact food shelf life.

Williams *et al.* (2012) found that 20-25% of household food wastes are packaging-related, highlighting the need for improving packaging systems and investment in packaging research and innovation transfer. Whether “better” packaging that increases shelf life or makes it easier to get the last bit of food out of the package results in a net environmental benefit can be very case specific.

Often, changes in packaging can lead to reductions in food waste, even though these changes, such as increases in packaging weight or a shift to a nonrecyclable material, may be perceived as undesirable. Several studies have found that the environmental impacts of packaging are relatively small compared to that of the packaged food (Wikström & Williams, 2010). The literature demonstrates that changes in food packaging that lead to food waste reductions can result in net reductions in environmental impacts, even if the impacts of the packaging itself increase. The role of packaging in reducing food waste resulting in an overall positive environmental impact on a global scale is receiving increasing attention.

When the focus is collection and recycling, the protective role of packaging is often disregarded by neglecting to look at the entire system. This narrow perspective has resulted in the view that packaging is a waste of resources. Many sustainability efforts are aimed at reducing packaging waste, where packaging is considered as a stand-alone product, and thus a stand-alone environmental burden, leading to a failure to differentiate between "useful" and "wasteful" packaging. Packaging that fulfils its task of ensuring safe delivery of the packaged food while minimising food waste can contribute to sustainable development. In the sustainable food packaging conversation to date, little attention has been given to packaging's ability to contribute to net reductions in environmental impacts by reducing food waste.

Limited recognition has been given to the balancing act that arises between the environmental impact of producing and disposing of the packaging itself and its ability to reduce food waste and its associated environmental impacts along the food value chain (Licciardello, 2017). Not including food waste may lead to contradictory results, favouring less packaging material per unit of food. Heller *et al*. (2018) suggested a″food-to-packaging (FTP) ratio″defined as the environmental impact indicator of interest such as GHG emissions or cumulative energy demand for agricultural (farm gate) production and food processing, divided by that for packaging material production based on a kg of food consumed. They reported FTP ratios for GHG emissions ranging from 0.06 for wine to 780 for beef.

For some foods, such as leafy greens, where agricultural production burdens are small and FTP ratios are low, the focus should be on reducing the impact of the packaging through light-weighting, alternative material selection, etc. For foods with high FTP ratios such as cereals, dairy, seafood and meats, food waste dominates the trade-off with packaging impacts, and greater opportunity exists for net impact reductions through packaging-based food waste reduction innovations. Heller *et al.* (2018) illustrated both the importance of considering food waste when comparing packaging alternatives, and the potential for using packaging to reduce overall system impacts by reducing food waste. This is the evidence-based approach to minimising food waste but many consumers and legislators prefer an approach based on perception and myth rather than evidence as the recent anti-plastics movement demonstrates.

Anti-plastics Movement

As the use of plastics in modern society has increased, so too has the environmental impacts associated with its production and disposal. Of the 8.3 billion tonnes of plastics produced since the 1950s, 5.8 billion tonnes were used only once. Of this single-use plastic, only 9% has been recycled and another 12% incinerated; the rest (4.6 billion) ended up in landfills or the natural environment. It could all have been dumped in a landfill 70 metres deep and 57 square kilometres in area - that is to say, the size of Manhattan (Geyer *et al.,* 2017).

About 8 million tonnes of plastic waste end up in the ocean annually, where it can be ingested by marine animals with fatal consequences. Ten rivers (two in Africa and the rest in Asia) discharge 90% of all plastic marine debris. The Great Pacific Garbage patch, first reported in 1988, has a low density of 4 particles per cubic metre and covers an area of 1.6 million km^2. Fishing nets account for 46%, with the majority of the remainder composed of other fishing industry gear; 20% is debris from the 2011 Japanese tsunami. The high visibility of plastic marine debris, highlighted through popular television documentaries, has resulted in a war on single-use plastics, although the fact that all metal food cans and glass bottles are also single-use is ignored.

In August 2018 a major UK supermarket chain announced that it would no longer shrink-wrap cucumbers. The 1.5 g of polyethylene extended the shelf life of a cucumber from 3 to 14 days, and the move will prevent 16 million plastic sleeves being used each year. However, the plastic-free cucumbers will only be available from March until October when they are sourced from British growers, as imported cucumbers will continue to be shrink-wrapped. The increase in waste due to a reduced shelf life appears not to have been factored into this decision.

Two large trade bodies representing manufacturers of plastic resins and packaging materials have made public commitments. The American Chemistry Council's (ACC) Plastics Division has announced that 100% of plastics packaging is to be recyclable or recoverable by 2030, and 100% of plastics packaging is to be reused, recycled or recovered by 2040. The European plastics manufacturers have also committed to ensure high rates of reuse and recycling with the ambition to reach 60 per cent for plastic packaging by 2030, helping achieve their goal of 100% reuse, recycling and recovery of all plastics packaging at European level by 2040.

Multinational food companies have also made public commitments. Coca-Cola wants to help collect and recycle bottles and cans for every one it sells by 2030, to which Greenpeace responded that Coca-Cola should focus on reducing, not recycling, waste. Danone's Evian, Unilever and PepsiCo have announced similar steps to encourage greater recycling and less plastic. McDonald's plans to make all its packaging from recycled or renewable sources by 2025 (currently 50%). While these commitments are commendable, packaging must be collected and sorted before it can be recycled and this is a very expensive step. The lack of end markets for the recycled plastics is also a challenge.

A recent study found that the environmental cost of using plastics in consumer goods and packaging is nearly four times less than it would be if plastics were replaced with alternative materials

(Trucost, 2016). That is because strong, lightweight plastics enable more to be done with less material, which provides environmental benefits throughout the lifecycle of plastic products and packaging. This study was based on natural capital accounting methods, which measure and value environmental impacts such as emissions to air, land and water which are not typically factored into traditional financial accounting. The study also concluded that the environmental costs of alternative materials can be lower per tonne of product but are greater in aggregate due to the much larger quantities of these alternative materials needed to fulfill the same purposes as plastics.

A cost-benefit analysis showed that the benefits of PET recycling in Europe outweigh additional costs (positive cost-benefit balance) but the benefits of domestic film recycling do not (negative cost-benefit balance). The maximum eco-efficient recycling level for plastics packaging was somewhere between 36% and 53%. Recycling beyond this limit will either be low quality recycling (no environmental benefits) or will not be eco-efficient due to very high costs (Pilz *et al*., 2010). Despite these findings, recycling targets for plastics in the EU have been increased; the overall goal is to reach 55% plastics waste recycling by 2030. Currently only 26% of plastic waste is recycled in EU-28. Impediments to higher plastics recycling are lack of demand, poor collection rates and a fragile market.

Conclusion

An evidence-based approach to sustainable packaging must be adopted to find the balance between protection of the food and packaging material use. Such an approach can lead to an overall saving in resources, reduction in waste, lower environmental impacts and an increase in overall system efficiency. Current anti-plastic campaigns risk distorting outcomes and encourage virtue signaling (the conspicuous expression of moral values done primarily with the intent of enhancing standing within a social group) by companies. As well, the focus on recycling rather than overall sustainability also risks distorting outcomes.

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Useful Links

American Chemical Council Plastics Division https://plastics.americanchemistry.com/
Consumer Goods Forum http://media.theconsumergoodsforum.com/consumer-goods-industry-moves-to-act-on-plastic-waste/
Ellen MacArthur Foundation https://newplasticseconomy.org/projects/global-commitment
EUROPEN https://europen-packaging.eu/news/news/122-joint-statement-from-68-packaging-value-chain-associations-on-the-proposal-for-a-directive-on-the-reduction-of-the-impact-of-certain-plastic-products-on-the-environment.html
Greenpeace https://www.greenpeace.org/international/publication/19007/a-crisis-of-convenience-the-corporations-behind-the-plastics-pollution-pandemic/
Incpen https://www.incpen.org/sustainability-checklist-for-packaging/
Plastics Europe https://www.plasticseurope.org/en/resources/publications/274-plastics-facts-2017
Sustainable Packaging Coalition https://sustainablepackaging.org/
US Environmental Protection Agency https://www.epa.gov/smm/sustainable-packaging
WRAP http://www.wrap.org.uk/category/subject/packaging

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The International Union of Food Science and Technology (IUFoST) is the global scientific organisation representing more than 300,000 food scientists and technologists from over 75 countries. IUFoST is a full scientific member of ICSU (International Council for Science) and it represents food science and technology to international organizations such as WHO, FAO, UNDP and others.

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