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Packaging Design and Environmental Sustainability: Evaluating the Plastic Carry Bag for Effective Design

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Abstract

Waste is created out of the use and disposal of packaging. Amount of resources used for packaging production and the waste generated thereof are threats to environmental sustainability if not managed properly. This research assessed consumers understanding and practice of sustainable packaging and its effect on the environment. Plastic carrier bags were also assessed for their environmental sustainability and an alternative design suggested to replace them using the criteria set by Sustainable Packaging Coalition. Observations were that consumers did not have knowledge about sustainable packaging. However, a high proportion of the consumers practiced reusing of packaging, which was a positive attitude for environmental sustainability. The study found out that reusing was environmentally friendly; consequently, the single use plastic bags were environmentally unsustainable. Alternative design that meet the requirements of the market and addresses the environmental impacts of importance have been suggested. For consumer's participation in sustainable packaging, they have to be continuously educated on sustainability concepts and the role of packaging in sustainable development.

Keywords: environmental sustainability, packaging design, reuse

INTRODUCTION

Whatever humans need to survive is directly or indirectly dependent on the natural environment (Alison et al., 2016). Packaging which ensure delivery of goods to the ultimate customer in the best condition intended for their use is not an exception and has an interrelated dependency on our environment (Brody and Marsh, 1997).

Packaging has been discussed as an environmental problem within society for many years**.** The debate has mainly focused on the environmental problems of the packaging material (Robertson, 2006). There are various types of packaging materials used globally. In Ghana, the most common are plastics, wood, paper, glass and metal. Preference for plastics in the past two decades for food and water packaging has contributed to their large rise in the waste streams in Ghana and globally (Fobil and Hogarh, 2009). Plastic waste puts immense strain on the environment due to their non-degradable nature.

The environmental protection agency in collaboration with other waste management agencies in Ghana has tried to clear the environment of waste to enable environmental sustainability (Mensah, 2006; Crook and Ayee, 2006). Despite these efforts the environment still suffers from pollution as a result of solid waste disposal. Packages are a major part of these solid waste produced. The presence of packages in the waste stream may be due to their excessive use or lack of carefully thought out disposal plans. The environmental footprint of these packages can be reduced through renewable or reduced energy use; reduction of the necessary raw materials and other resources; use of design-for-recycling principles; incorporation of recycled content in the package; and sound and accessible end-of-life options for the packages, such as recycling (Napcor, 2009).

Consumer involvement and participation is required to succeed in the prevention of origination of waste, recycling and development of sustainable packages (Th'gersen

& Grunert-Beckmann, 1997). The past decade has witnessed a marked increase in consumer behaviour research focusing on recycling at the household level (Pelton et al., 1993). However, even though recycling of waste is an indispensable element of solving the waste problem, it is only a second-best solution as not all waste materials are recovered, while resources are wasted in the transportation and processing of recyclables.

According to Th'gersen and Grunert-Beckmann (1997), a preventive waste management approach with focuses on changes in lifestyle, production and consumption patterns, offers the best chance of reversing current trends. The easiest way to save resources and energy and to cut down on waste is to use less. Waste minimisation covers activities that a person performs in order to reduce his or her contribution to the waste stream. Consumers may perform waste minimisation by buying beverages in refillable bottles, reuse plastic bags, repair broken household items, or source separating their waste.

Zoomlion Ghana Limited, a subsidiary of the Jospong Group of Companies, has inaugurated the Accra Waste Recovery Facility, a US$20million ultramodern integrated recycling and compost plant in Accra, the capital. The plant is designed as multi-purpose with the capacity to process plastics into pellets and discover other materials, such as paper and electronic waste among others, and turn them into raw material for industry. The Plant has a 90 percent waste-recovery rate with the capacity to handle 800 metric tonnes of solid waste on a sixteen-hour shift; and an additional 200 tonnes of compost per day to support the agricultural and horticultural sectors (Business and Financial Times Online (2019).

Implicitly, Ghanaian designers can now create packages, which would be recycled at the end of their life cycle. However, with this single plant located in Accra, the cost of collection and transportation of waste to the plant from the other parts of the

country would be too high or even impracticable to merit its use. Alternative environmentally sustainable packaging approaches therefore need to be applied.

Package designers in Ghana have tried eco-friendly or biodegradable plastic materials (such as oxo-biodegradable) for their packages but their widespread use have proven unsuccessful due to the unavailability and high cost of these packaging materials (Avella et al., 2005; Van den Oever et al., 2017). Additionally, recent studies show that the biodegradable properties of plastics prevent their use for certain food packaging applications (Rhim et al., 2013; Van den Oever et al., 2017). Consequently, the immediate available option would be for designers to work with locally available materials with the participation of consumers in the design process. The challenge however would be how to effectively develop packages with these locally obtainable materials that ensures environmental sustainability.

Globally plastic carry bags have become products of environmental concern (Lewis et al., 2010). In Ghana, plastic carry bags are perceived to impact negatively on the environment by consumers, government and environmental organizations due to their low recovery rates at end of life, high visibility in scattered litter in the environment and blocked drains (visual pollution), and consequent ecological implications such as harm to marine life, livestock, and wildlife. As a result of these concerns, the government of Ghana is considering regulations to reduce or ban the use of disposable (single use) plastic carry bags (Rayne, 2008; Clapp and Swanston, 2009). African countries such as South Africa, Kenya, Rwanda, Tanzania, and Uganda have already ban the use of plastic carry bags. In Australia, plastic carry bags have been a focus of environmental campaigns since the early 1990s, due to their negative environmental impacts (Lewis et al., 2010). In view of the enormity of the perceived implications of plastic carry bags on environmental sustainability internationally and locally; this research uses it as a case study to develop an alternative shopping carry bag.

This research therefore sought to develop an environmentally sustainable *shopping carry bag* with locally available materials using life cycle assessment and inputs from consumers to inform the design decisions. The specific objectives of the study were to assess consumers' knowledge, understanding and practice of sustainable packaging, and secondly, to assess the environmental sustainability of plastic carry bags and suggest an alternative design for it.

To successfully achieve the objectives of the research, the following research questions were posed: a) How is your understanding or knowledge related to the actual practice of sustainable packaging? b) How is your reuse pattern relevant to sustainable packaging design? The research questions guided the research activities in the exploration and development of an environmentally sustainable carry bag within a normative design framework.

Packaging is often thought of as a necessary evil in consumer and production-oriented economies. Properly designed packaging contains, preserves and protects natural or manufactured products from deterioration and damage, and attractively presents products to consumers (Paine, 2002). The drawback to these advantages is that more than 6.5 million tons of plastics are dumped each year in the oceans and a lot of packaging waste ends up in landfills. Most of these packages are made of finite resources. Consequently, environmental sustainability or sustainable development has become a major concern in the total life cycle of a package.

Sustainable development according to The World Commission on Environment and Development (1987), is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The guiding principles for sustainable development is hinged on the three pillars of social equity, environmental protection and economic prosperity in a balanced manner (Alshuwaikhat and Abubakar, 2008). Sustainable packaging or "green" packaging

must therefore first and foremost serve its essential functions of protecting the product it contains, delivering it safely with all of its features and benefits intact. Beyond this, sustainable packages have reduced environmental footprint through use of renewable or reduced energy, reduction of the necessary raw materials and other resources, use of design-for-recycling principles, incorporation of recycled content in the package, and sound, accessible end-of-life options such as recycling of the package (Napcor, 2009; Lewis et al, 2007).

Large portions of the resource use and the greenhouse gas emissions have their origins in the production of goods that we consume and use in our daily lives. Since majority of goods are packed, packaging certainly affects both resource use and greenhouse emissions in different ways. Additionally, transportation of goods results in emissions, congestion and noise. Packaging indirectly affects volume and weight of products which in turn affects transportation dramatically. Sustainable package design reduces the transport impact of global distribution chains. Good packaging design can reduce the fuel use per product by allowing more products to be palletised and more pallets on each truck, train, boat or plane. This means fewer journeys, less energy use and less climate impact. Using lighter packaging materials also reduces the fuel used in distribution. Another way to reduce greenhouse gases is to increase the use of renewable raw materials or recycled materials, in addition to carefully using and protecting the limited natural resources.

The designer's role in environmental sustainability is a concept which involves the designer's knowledge or understanding of the impact the decision he makes has on the environment. By taking an informed approach to the way design decisions are made, beginning with an understanding of how every choice affects the environment; designers can begin to help mitigate the impacts of packaging on the environment (Porter and Van der Linde, 1995; Steelcase, 2007). Some of the tools that are available to the designer to make informed decisions are the guidelines

presented by the Sustainable Packaging Coalition (SPC) of USA and Sustainable Packaging Alliance (SPA) of Australia and the application of the three R's in the design process. In effect the designer must have a life cycle thinking in order to prevent piecemeal approaches and avoid problem shifting from one stage to another. The designer must therefore think of the end of the package from the beginning (Jedlicka, 2009). Effective decision options on the end of the package could be achieved by following the principles of the European Waste Hierarchy Directive (Figure 1) (Dominic et al., 2014). In using this model, the designer balances packaging material avoidance with material disposal in the supply chain.

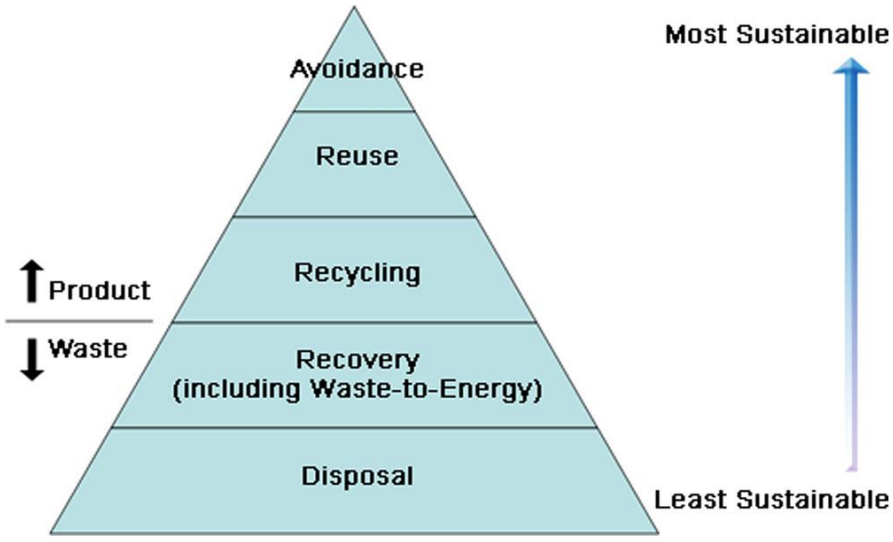

Figure 1. Waste hierarchy model

Sustainable packaging design is broadened by the principles presented by the SPC of USA. The SPC's definition of sustainable packaging identifies eight principles which when considered together in assessing or designing packaging results in improvements that contribute to the broader triple bottom line goals of sustainable development (SPC, 2006). According to the criteria set by SPC, packaging must:

- be beneficial, safe and healthy for individuals and communities throughout its life cycle

- meet market criteria for performance and cost
- be sourced, manufactured, transported, and recycled using renewable energy
- optimize the use of renewable or recycled source materials
- be manufactured using clean production technologies and best practices
- be made from materials healthy throughout the life cycle
- be physically designed to optimize materials and energy
- be effectively recovered and utilized in biological and/or industrial closed loop cycles.

Application of these principles results in packaging that demonstrate social, economic, and environmental benefits (SPC, 2006).

METHODOLOGY

This is an applied research, which seeks to determine how environmental sustainability of packages could be improved through package design. Strategies adopted included evaluation of the life cycle of packages, effective or lean designing to ensure reduction of the package material and incorporation of consumer views in the design process. The study analysed plastic carry bags used on the Ghanaian market, and proposed an alternative design which would best suit the physical environment as well as serve the purpose of effective packaging.

Research design

Sources of information for this research included literature from published journal papers, books, data from governmental and non-governmental environmental agencies, packaging companies and institutions and student theses.

The study further attempted to ascertain the causes and effects of excessive packaging waste using causal comparative research design. This research approach was suitable as it determines the causes or consequences of differences that already

exist between or among groups of individuals or items (Fraenkel et al., 1993; Schenker and Rumrill Jr, 2004). Additionally, the independent variables under discussion (package material and design) cannot be examined using controlled experiments. Hence, a research design which makes use of comparison of two variables in similar situations was appropriate.

The study population was chosen from KNUST and its environs in Kumasi, where both local and imported packaged consumer products are distributed and sold in most supermarkets and shops. In addition, there are small retailers who are spread almost everywhere in the suburbs. The population in this area is considered to be exposed to various types of package designs and materials. Their accumulated knowledge and experiences with these package materials were essential to testing the new design. Views of consumers on the plastic carry bags and information for designing the new package were obtained using questionnaires. Through Simple Random Sampling approaches, three hundred and sixty-four (364), being the consumer response population out of the targeted figure of four hundred (400) was obtained. The respondent rate of 91% was statistically significant, representatively acceptable and reliable because it ensured in-depth analysis and provided the needed comprehensive research reach. A consequence of this is the distillation of an actionable alternative design framework for the carrier bag.

Assessment of the sustainability of packages

The plastic carry bags and its alternative design were assessed for their environmental sustainability based on the criteria set by the Sustainable Packaging Coalition (SPC) (SPC, 2006). These criteria are design guidelines that help in the integration of sustainability and environmental considerations into the packaging design process (SPC 2006). The criteria help designers focus on the appropriate questions to ask to develop environmentally sustainable packages.

RESULTS AND DISCUSSIONS

Consumer Understanding and Practice of Sustainable Packaging

Information from Figure 2 shows that consumers lacked knowledge and understanding of sustainable packaging. Only 22% of the consumers admitted to knowing what environmental sustainability is (Figure 2). This finding is consistent with the results of other researchers. For instance, in a study by Young (2010) on "Packaging and the environment; a cross cultural perspective", he found that less than 20% of the consumers in the USA, the UK, and Germany knew what the term sustainable packaging meant. Raymond (2009) similarly reported that most consumers across all generations do not have knowledge of all the elements of sustainability but rather understand sustainable packaging as recyclable packaging. Even that, many had little or no knowledge about the type of packaging material that can be recycled (Raymond, 2009).

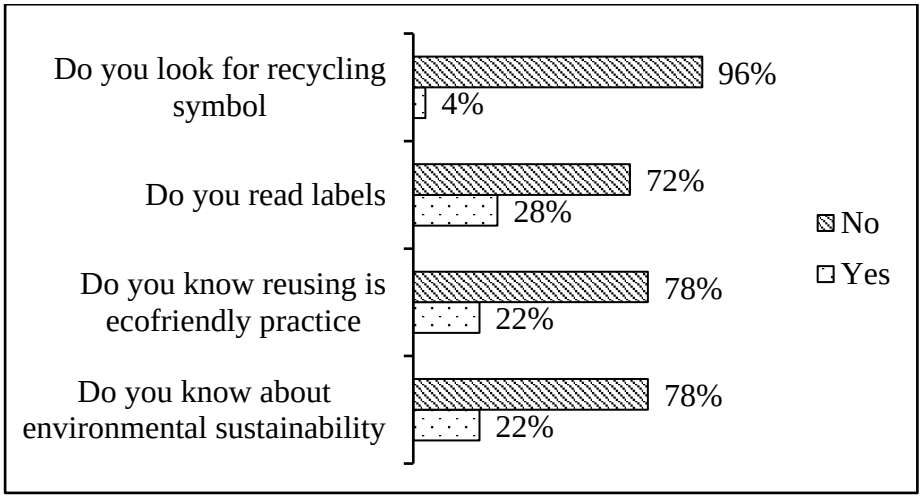

Figure 2. Consumer Understanding and Practice of Sustainable Packaging

The lack of knowledge of sustainable packaging is supported in this study by the high proportion (78%) of the studied population being ignorant about the fact that reusing of a package promotes environmental sustainability. Again, consumers' unfamiliarity with the concept of sustainable packaging is demonstrated in their lack of involvement in recycling of packaging apparently due to the lack of infrastructure for recycling or the absence of the culture of recycling (Figure 2).

Figure 2 also depicts that 96% and 72% of the respondents do not look for the recycle symbol and read label on packaging, respectively. Only 28% of the consumers read labels on packaging. This makes labelling a weak method of communicating product information sensitizing consumers, since less than half of the population would pay attention to it. The findings of this study and that of other researchers underscores the need to invest time and energy to educate consumers about sustainable packaging and sustainable development and their benefit to the society and environment.

Consumer Responses Relevant for Sustainable Packaging Design

Figure 3 shows that 8% of the studied population reuses plastic carry bags after first use. This implies that the remaining 92% are disposed of into the waste stream. This finding is somewhat consistent with the work of Ayalon et al., (2009) who indicated that about 6% of plastic carry bags are reused by consumers to pack product for outdoor use in Israel which eventually end up as litter in the environment. The current study also found out that 82% of consumers discard emptied packaging in dustbins. This rate of disposal of packaging and the plastic carry bags is not sustainable.

In using the waste hierarchy model as the objective, packaging which are designed for disposal after first use are the least sustainable option. A better option would be to provide for consumers packaging that uses optimum amount of material and the

material are adapted to recovery strategies such as reuse or recycling (Calver, 2004; Dominic et al., 2014).

In spite of the fact that 78% of the consumers indicated that they did not know that reusing packaging was environmentally friendly practice (Figure 2), 60% of them were observed to practice reusing (Figure 3). This is encouraging as designers can consider materials and designs for packaging that would be adapted to reuse to ensure environmental sustainability.

Several Life Cycle Analysis (LCA) studies have proven that reusable carry bags are the preferable option to single use bags (Lewis et al, 2010). An example of such study

is the streamlined LCA by Lewis et al. (2010) which combined LCA modeling with qualitative review of disposal and recovery options for seven carry bags.

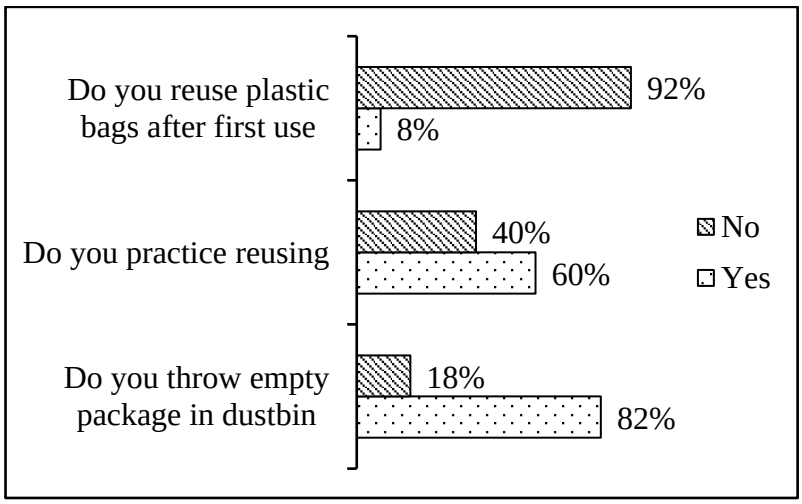

Figure 3. Consumer Responses Relevant for Sustainable Packaging Design

The evaluated bags were single-use HDPE bag, single-use HDPE bag with recycled material, single-use biodegradable plastic bag, single-use oxo-degradable plastic bag, single-use paper bag, reusable 100% recycled PET bag, and reusable PP bag. Assessment was based on eight environmental impact categories including global

warming photochemical oxidation (smog), eutrophication (nutrients released into water ways), land use, water use, solid waste, fossil fuels and minerals. Lower environmental impacts were recorded for the reusable bags (PET &PP).

A sensitivity analysis however, showed that the benefits accrued to reusable bags is dependent on the number of times each bag is used during its life. The study recommended that reusable bags be used at least 50 times to ensure that the sustainability benefits are realized (Lewis et al., 2010).

Assessment of Plastic Carry Bags and Reusable Graybaft Carry Bags as Design Options

According to Lewis et al (2010), all forms of packaging have impacts on the environment. The environmental impact of importance to the populace influences the decision on the preferred packaging option (materials and design). In Ghana the biggest environmental consequences of the use of plastic carry bags is the profuse littering of the environment and water bodies and the chocking of drains and water ways due to the lack of infrastructure for collection and recycling and hence the lack of the practice of recycling by the populace. Most of the plastic bags are also disposed of at landfills. Implications are that in the consideration of the consumers perspective in taking a decision about sustainable grocery carry bag option, a reusable material that is also biodegradable may be the best option.

In assessing locally available materials as alternatives to plastic for the grocery carry bag, graybaft a cotton fabric was chosen. Graybaft is a flexible woven material consisting of a network of natural cotton fabrics (thread or yarn). It is strong, biodegradable, and can be used several times.

It must be emphasized that decisions on the sustainability and best design choice for the grocery carry bag must take into consideration the environmental impacts of the

options. Presented in Table 1 is the sustainability evaluation of the graybaft bag in comparison to the plastic carry bags, according to the criteria set by SPC.

Table 1. Comparison of Sustainability Impacts of Plastic Carry Bags and Reusable Graybaft Carry Bag as Design Options

Criteria	Plastic Carry Bag	Graybaft Grocery Bag
Is beneficial, safe, and healthy for individuals and communities throughout its life cycle	• The manufacturing process uses less water than the graybaft. This implies that it generates less waterborne waste. • Produces low greenhouse gas emissions per bag due to the small amount of material used to make the bags. In comparison to the graybaft the emissions are high since many plastic bags may be used in place of one graybaft bag. • Bags may be ingested by wildlife as food	• The manufacturing process uses more water and therefore generates more waterborne waste than the plastic bag • It's a renewable resource. The use of fertilizer in its cultivation and decomposition in landfill may release greenhouse gases but to minimal extent. • It is unlikely that littered bags will be hazardous to wildlife because they will not be mistaken for food. • The bags have a higher strength to weight ratio but poor moisture barrier compared to plastic carry bags. They can be used for all products but may not be suitable for wet products.
Meets market criteria for performance and cost	• The bags have high strength to weight ratio and good moisture barrier. They can be used for all products.	

Table 1. *Continued*

Criteria	Plastic Carry Bag	Graybaft Grocery Bag
	• The bags capacity is about 5-7 grocery items • Bags are convenient for consumers. They are lightweight, given out free and consumers do not have to take bags with them to the store. Bags can be reused for several applications such as bin liners • Supermarket retailers find it convenient as it cost very little and allows fast packaging of goods.	• The bags capacity would be about 7-9 grocery items. • The bags can be reused many times for shopping due to its high durability • The bags may be less convenient to consumers since they have to remember to take them along for shopping • The use of the bags will save retailers the cost of stocking single use plastic bags • The bags will be more convenient to consumers since they would have larger capacities. • Bags can be mended when damaged.
Is sourced, manufactured, transported, and recycled using renewable or recycled source materials.	• The bags are not transported using renewable or recycled source materials (uses fossil fuel) • The weight of a bag in a car will have very little effect on fuel efficiency.	• The bags are not transported using renewable or recycled source materials (uses fossil fuel) • The weight of the bags in a car will have very little effect on fuel efficiency.

Table 1. *Continued*

Criteria	Plastic Carry Bag	Graybaft Grocery Bag
Optimises the use of renewable or recycled source material.	• The bags are not made from renewable materials. They are made from natural gas and oil. • The bags can contain some recycled material • There is no infrastructure for collection and recycling of plastic bags.	• The bags are manufactured from renewable resources. • The bags do not contain recycled materials. • There is no infrastructure for collection and recycling of the bags
Is manufactured using clean production technologies and best practices.	• The manufacturing process uses more energy compared to the graybaft bags • Technically plastics are recyclable. • Currently due to the lack of infrastructure, plastic carry bags are not recycled.	• The manufacturing process uses less energy compared to the plastic bags
Is made from materials healthy in all probable end of life scenarios	• Plastic bags end up at landfills and as litter. They are relatively inert in these environments and their gestation time for degradation is unknown (possibly hundreds of years).	• The bags will not be recycled but reused for shopping many times. • The bags will eventually end up at landfills and break down anaerobically over time and release greenhouse gases. • May have higher impact on eutrophication (nutrients to water ways) if littered.

Table 1. *Continued*

Criteria	Plastic Carry Bag	Graybaft Grocery Bag
Is physically designed to optimise materials and energy.	• The bags are lightweight and use minimal amount of material in their manufacture. • Many of them will be used in place of one graybaft bag.	• The bags are heavier and contain more material than the single use bags. • The bags will be reused many times compensating for the high material usage. • Will use some water and energy when the bag is washed.
Is effectively recovered and utilized in biological and or industrial closed loop cycles.	• Plastic bags do not end up in closed loop cycle but rather at landfills and as litter in the environment. This pollutes and aesthetically affects the environment.	• Bags are biodegradable and will decompose to ensure a closed loop cycle. • Bags can be included in biological recovery systems such as composting and anaerobic digestion for energy recovery.

CONCLUSIONS

The objective of this study was first to determine consumer's knowledge, understanding and practice of sustainable packaging. Findings from this initial survey were then used in conjunction with outcomes of sustainability assessment of grocery plastic carrier bags to design an alternative environmentally sustainable grocery carrier bag.

Results from the consumer survey revealed a lack of knowledge and understanding of the sustainability concept and its application. Consumer interest in sustainable packaging was also observed to be minimal as they did not look for the recycling symbol or read labels to find out how to handle packaging after its content usage. A

recommendation therefore is for consumers to be educated on sustainability concepts and the role of packaging in sustainable development.

Data analysis showed that the best option were alternative designs that could be reused many times, are biodegradable and capable of reducing environmental litter. The biodegradable graybaft bags suggested is therefore a good alternative to the plastic carrier bags. It is recommended that the graybaft bags are used many times to derive the ultimate sustainable benefits.

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