

Sustainability in Product Design and using it for designing organic food containers

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Abstract

The use of raw paper and single-use plastic containers in the processes of packaging and containing food and beverages is widespread, after the exacerbation of their damages to the environment, and since the research problem relates to the spread of intermediate containing products, and the diversity of their raw material, without taking into account the negative impact some of them have on the environment, it was necessary to search for alternative materials that are healthier, more sustainable, and less hazardous to the environment and which are degradable and usable repeatedly. Therefore, the research objectives are summarized in shedding light on sustainable, degradable materials that reduce the damage to the environment instead of increasing it, especially those local materials that are easy to obtain at low cost. The importance of the research revolves around introducing the wasted materials that can be used in the processes of packaging and containing products. The research is also concerned with clarifying the idea of the re-use of intermediate containing products because of their positive impact on the environment. The results of the research introduce raw materials, including local ones, which can be used as an alternative to the raw materials that are harmful to the environment. It pinpoints the differences between both categories and the advantages of the former. There is also an emphasis on the possibility of benefiting from agricultural waste and engaging farmers' interest through the profit they can gain from the manufacturing process. The results clarify some ways of applying the idea of re-use and re-packaging to reduce wastes as well. The product design process introduced a sustainable design which was proposed for a leading organic food company, and it was nominated for the stage of match-making with companies in a competition organized by the Nilepreneurs Initiative. The product design concept was used as a strategy for designing packaging containers which give the producing company a special and distinct identity.

Keywords:

Sustainable design, sustainable products, organic food, biodegradable materials, product design.

Introduction

The environment represents everything that surrounds Man, and he/she constantly affects, and is affected by it. Whatever impact Man has on the environment, negative or positive, is equally returned to him/her. Given that a designer is the one who innovates and creates everything new in order to achieve comfort and benefit for humanity, he/she has to consider his/her design and its life cycle starting from the stage of developing the idea, passing through the design stage, the production and use stages, and reaching its end-of-life stage.

Choosing the packaging method and its related materials is an important process due to the fact that the materials used are usually harmful to the environment. The packaging containers are usually made of paper, the production of which causes huge amounts of forest trees to be cut down and thus destroyed, and it also consumes large quantities of water. Alternatively, they can be single-use plastic products whose manufacture consumes a large amount of water and great energy. At the end of their life cycle, they are non-degradable and cannot be reused or recycled. More precisely, it can be said that only 3% of the roughly 500 billion plastic bags produced annually are recycled.

It is unfortunate to say that the first plastic container manufactured in the world still exists on the surface of the earth until this moment. These containers end up in rubbish dumps or in the seas and rivers. Animals usually eat them mistaking them for food which leads to their death, thus disrupting the ecosystem. Moreover, plastic nanoparticles find their way to humans' body through animals in their food chain or through water. Therefore, it was necessary to search for other alternative materials that would not result in such harm to the environment nor to humans.

Problem Statement

The research problem pertains to the spread of intermediate containing products made of diverse raw materials with inadequate consideration of their impact and harm on the environment and on human health.

Hypotheses

- There is an inverse relationship between the huge environmental damage that occurs and the use of biodegradable materials in the manufacturing of the widespread intermediate products.
- The low cost of the natural local materials usable in the production of intermediate container products is one of the most important reasons that can automatically turn the attention of companies to the environment.

Research Objectives

- Shedding light on sustainable and biodegradable materials for the benefit of designers in Egyptian companies and institutions in an initiative to use them as an alternative to single-use plastic products.
- Presenting a design proposal for the organic food packaging containers produced by a leading company in the field of organic food.
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Research Significance

- Introducing local wasted materials that can be used in the manufacture of containers that would reduce the damage to the environment and prevent incurring more harm.
- Shedding light on the notions of re-use and refilling instead of packing the main products into single-use intermediate products.

Research Methodology

The study relies on the descriptive, analytical, comparative, and experimental research methods.

- Descriptive Research: It was used to accurately describe our design experiment and the processes involved in it.
- Analytical and Comparative Research: It was used in comparing and contrasting the different sustainable materials that affect the environment one way or another.
- Experimental Research: It was used in the sustainable designs proposed for a leading company in the field of organic food.

Research Sample

- A group of different sustainable materials that are suitable for containing organic food.
- A proposed sustainable intermediate product design for a leading organic food company.

Definitions

Sustainability: It was defined by the World Commission for Environment and Development as "Meeting the needs of the present without compromising the ability of future generations to meet their needs."

Sustainability has three dimensions – economic, social, and environmental -- as the institution's course for achieving economic growth should not come at the expense of the environment or result in unhealthy working conditions or unfair wages.

Sustainable Design: It is a term used to describe the use of sustainability principles in the design and development of commercial and industrial products. The objective is to provide social and economic benefits while protecting public health, securing welfare, and protecting the environment from harmful emissions throughout the life cycle of the product.

Sustainability Patterns in Design

Sustainability in design has two forms:

- 1- Design for Disassembly: It is the design of the product in a form that can be disassembled and reassembled, which allows the reuse or recycling of parts of it.
- 2- Cradle to Cradle: It is the design where the product at the end of its life cycle is the entrance to a new system or product so that the process is carried out systematically.

A product's life cycle is divided into four stages.

First: The Design Stage

It is the stage with the greatest impact as it is responsible for 80% of the environmental emissions that result during the product life cycle. The designer should make adequate studies regarding the appropriate types of raw materials and production methods that are less harmful

to the environment, economy, and public health. Among the most important aspects that a designer must take into account are:

- Material efficiency
- Efficiency of use
- Reliance on degradable or recyclable materials
- Re-use
- Dependence on clean energy
- Safety
- Social Impact

The designer must also work on trying to reduce wastes and uproot them from their original sources which are basically:

- Overproduction
- Transfer and transportation

Second: The Production Stage

It is a stage that results in a large percentage of the pollution generated during the life cycle of the product, and this pollution is represented in the various wastes resulting from that process.

Third: The Use Stage

It is the longest period in a product life cycle, and it can be made more sustainable. The life of a product can be increased if it is possible to disassemble and reassemble as this would make it easy to replace and repair the damaged parts if it breaks down. It is necessary also to make a product's shape attractive so that a user would not be influenced by other products that he wishes to replace his own.

Fourth: The End-of-Life Stage

After the life of a product ends, it turns into waste, which is a burden on the environment. However, there are some ways of avoiding this:

- Reuse of the Product:

This is done by designing the product for reuse by making it easy to disassemble and reassemble. In this way, it becomes easy for its parts to be repaired by the producing company so that it can be reused for the same purpose.

- Recycling Product Material:

This is done by using the raw materials of a product after the end of its life span, i.e. recycling them for use in other manufacturing processes, e.g. using paper in packaging and wrapping operations.

Eco/Environmental Labels

Environmental labels represent one of the environmental management tools which are in turn the subject of the International Organization for Standardization series ISO 14000. Environmental labels as well as environmental declarations provide information about a product or service from the angle of the overall environmental characteristic(s) or from the angle of a specific environmental dimension of a product or service, or any number of environmental dimensions.

Definition of Environmental Labelling

The Organization for Economic Cooperation and Development conducted a study in 1991 on environmental labelling where it established a definition for it as “The voluntary granting of environmental labels, by a public or private institution, for the knowledge and enlightenment of consumers, thus promoting the consumer goods proven to be environmentally preferable than the functionally and competitively equivalent products.”

In other words, “the eco- or environmental label is a well-known mark granted by an independent organization and placed on products that have obtained a license or certificate that they meet the conditions for granting this environmental mark.” In order for the environmental label to be beneficial, an increase in the price of labelled products must be applied. However, this increase in the price of the eco-labelled product necessitates a tangible degree of environmental awareness among consumers.

Environmental Label Objectives

- Protecting the environment, encouraging sustainable development, and reducing the consumption of natural resources.
- Creating awareness among consumers regarding the environmental impacts of each product or commodity they use.
- Creating an incentive for producers and importers to reduce the adverse environmental impacts of products.
- Improving the environmental specifications of commodities while encouraging innovative designs.
characterized with cost-effectiveness and environmental excellence.
- Granting producers with environmental labels is a competitive advantage over other producers.

In brief, environmental labels are a means or a tool for protecting the environment. At the same time, they represent a way to promote the concept of sustainability in production and consumption patterns.

The Subject of the Study

Our design journey began with an announcement about a competition¹ organized by the Egyptian Nile University. It is an annual competition for students only. It involves the participation of a number of companies that need unique proposed designs. We chose a leading Egyptian company of organic food² which set the following conditions for the required designs:

- Using economical and degradable materials.
- The packages must be transparent on top so that the consumer can see the product.
- Using very small amounts of plastic when required.
- Changing the old packaging designs for four organic products which are tomatoes, chili peppers, potatoes and leafy greens.



Figure 1: The Old Designs of the Containers to Be Changed

We started the design process by researching sustainable products and biodegradable materials. We compared these materials in terms of their sustainability, cost, light weight, ease of transport and storage, and their impact on health to find out the most appropriate material that suits preserving foods as well as organic and fresh vegetables. Below we briefly survey a number of raw materials:

Bagasse

The residues resulting after the extraction of juice from sugar cane that are used in the manufacture of paper and plastic alternatives. Its advantage is its being a renewable natural source that is decomposable within 120 days. The CO₂ gas resulting from its use in industries is less than that resulting from the use of plastic. It is also heatable and does not absorb any oils from food. In addition, sugar cane is a fast-growing plant.

1 Pack Designer 2020

2 Sara's Organic Food

Hemp Leaves

It is used in the manufacture of paper or plastic alternatives because it contains cellulose, it is biodegradable, non-toxic, and is characterized by strength and lightness. Egyptian institutions can contribute to social and environmental development by using unauthorized cultivated hemp in food packaging.

Rice Straw/Rice Husk

It is used in the manufacture of paper and plastic alternatives since its products are reusable. It is also a formable, fastly degradable, and a strong material suitable for use in microwaves and freezers. In addition, it is characterized by its thermal insulation.

Wheat Straw

Usually, this straw is burned by farmers, which increases pollution, though some people use it in the manufacture of alternative products to those that are made of plastic, since these products are characterized by moisture-resistance, high hardness, and light weight. This material is also biodegradable within approximately 60 to 90 days. Any plastic product can be replaced with another one made of wheat straw.

Palm Fibres

Palm fibres are used in the manufacture of packaging materials, and they are suitable for food packaging. They are considered a biodegradable material that decomposes within 90 days. This material is matte and opaque, has a smooth texture, its resistance to fire is weak, has a light weight, and is renewable.

Organic Plastic (PLA)

It is considered a natural alternative to plastic as it includes corn and sugar cane in its manufacture. It is biodegradable, but this depends on temperature and humidity. It is sent to industrial places for the process of its decomposition, which may not be in the capacity of some countries. Hence, it often ends up in oceans, seas, or rubbish dumps. If the required conditions are available, it decomposes between 8-12 weeks. It can be recycled due to the possibility of melting and re-forming it, and it melts at 180 degrees Celsius. It is authorized for use by the US Food and Drug Organization. Thus, it is safe for packaging food. It is characterized by being sensitive to heat, so it should only be used with cold drinks and foods, and it is also transparent.

Recyclable PET Containers

It is one of the types of plastic that is characterized by its transparency and recyclability. The emission rate of gases resulting from its manufacture is 70% less than that resulting in the case of other container products.

Moulded Pulp

It is made of recycled paper fibres and papers. It is one of the most sustainable packaging containers on the market today, and it is 100% recyclable.

Kraft Paper

It is a 100% environmentally-friendly, biodegradable paper with great flexibility and high resistance to tearing. It has been used for containing and packing products that need great durability and strength. It is the most popular and the most environmentally-friendly used material for container products in the world.

After doing a comprehensive study of the raw materials, it was agreed to choose organic plastic as a raw material for the design that was being worked on. A key factor for its selection was its transparency in addition to its biodegradability. Bagasse and rice straw were also chosen because they are two local raw materials that are often burned and not utilized. One of the most important advantages is that these raw materials will be a source of additional income for farmers and factories as they will sell them to be used in manufacturing. To determine which of the two materials would be used in our own product, we studied their respective manufacturing processes to know the environmental impacts resulting from them.

First: Making Paperboard and Dishes from Bagasse

Bagasse is stored wet in order to remove the sugar residue and the short fibres that impede its transformation into a paste. Then, it is mixed with water and environmentally-friendly and biodegradable bleachers, and additives are added in order to strengthen the mixture of bagasse

and water. The mixture is formed by pouring it into moulds as required, and the formation is done under high pressure and heat. Bagasse is obtained from sugar factories. Of every 10 tons of sugarcane, 3 tons of bagasse are produced, and to produce a plate of bagasse, 20 grams of it are needed.

Second: Making Paper and Dishes from Rice Straw

Rice straw is collected, cut, cleaned of impurities, and it is subjected to some chemical and mechanical processes in order to extract the pulp from it. Then, chemicals are added to whiten and lighten the fibres. After bleaching, those fibres are collected and sent to the production machine where the paste is made and rolled out in the form of paper sheets. These sheets are dried by heating or by exposition to the sun to be treated with water after that. It is worth noting that the machine for making paper from rice straw is less expensive than the regular paper machine. Ain Shams University students designed a machine to turn rice straw into paper.

Rice straw is a by-product of rice, and a total of 75 million tons of it are produced around the world. It is considered a renewable raw material annually produced locally. Thus, it would save hard currency, increase farmers' income when they sell it and create job opportunities. The price of a ton of rice straw in Egypt is 70 pounds. However, it has one environmental damage. During its manufacture, it produces a black liquid that is discharged into seas and rivers. Due to the environmental damage resulting from converting rice straw into paper, represented by this black liquid, choice settled on bagasse.

Reuse

We also studied the strategies of a number of companies that have implemented the idea of reusing the containers for their products. These companies include:

McDonald's Restaurants: Loop company designed reusable cups. When getting a drink, a deposit is paid for obtaining these cups. When returning the empty ones, that deposit is redeemed. The company then cleans and sterilizes the cups and reuses them for the drinks again.

Ampacet: This company, which is specialized in liquid and shower soap, made an experiment in Europe in 2019. It made its customers buy the product just once. After the container is finished, it is not thrown away but rather it is refilled by the suppliers of the company in the market.

Based on the selection of materials, ideas were developed about the shape of the proposed container. Focus was on making the design easy to store and that it would save space during transportation and reflect the identity of the company.

Brainstorming Stage

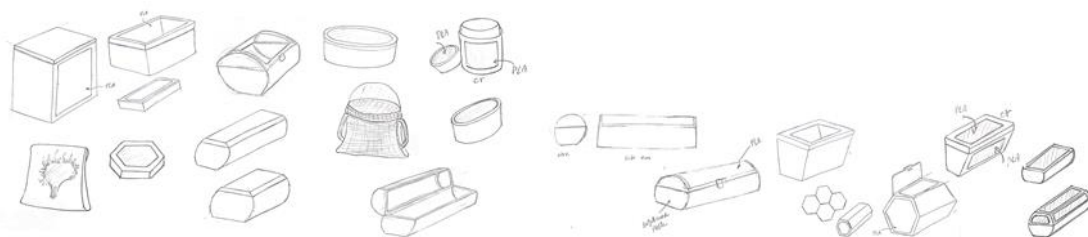


Figure (2): Some Initial Ideas for Designing the Intermediate Products
الحاوية.

Illustration Stage for the Selected Designs



Figure (3): Illustrations of the Selected Designs

Afterwards, we modelled the selected designs using the Rhinoceros 5 and Keyshot 6 programs to visualize their natural, three-dimensional shape. Then, we proceeded to design the labels for the container products. These labels are the visual aspect that attracts the eye. Hence, it is important that they reflect the identity of the company and include all the information about the product. The colours green, red, and yellow were chosen to reflect the colours of most vegetables and their different ripeness stages

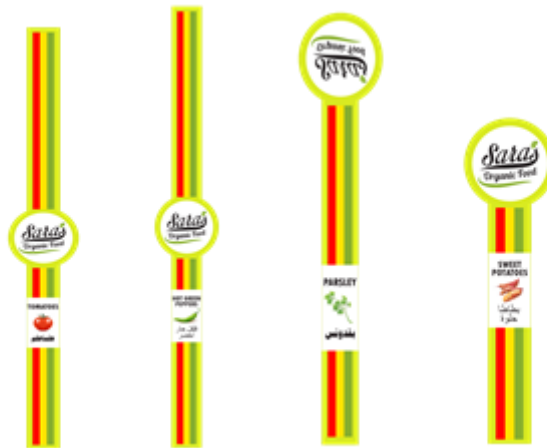


Figure (4): The Labels Designed for Packaging

We uploaded our designs on the competition website on October 18, 2020. On December 20, 2020, the competition committee sent an email with the selected designs nominating them for the next stage.

The Final Designs of the Intermediate Containers for the Organic Foods of the Leading Company



Figure (5): Products from Right to Left (Sweet Potatoes, Parsley, Hot Green Pepper, Tomatoes)

Results

- Alternative materials for single-use plastics were found that can be used in the containment of food and beverages.
- There are differences between the different sustainable materials in terms of their availability, durability, physical properties, time of decomposition, ease of manufacture, ease of renewal of their life cycle, their effect on food or not as well as their economics.
- Agricultural waste can be used in the manufacture of sustainable and biodegradable materials.

Recommendations

- Directing designers and researchers to give due attention to the environmental trends in designing the simplest products in cooperation with the Environmental Affairs Agency.
- Encouraging the manufacture of sustainable products using local materials by holding competitions and workshops.
- Urging the concerned institutions and companies to give due attention during the manufacture of their products to the profit farmers can gain.
- Spreading the ideas of reuse and refilling to reduce the volume of generated wastes.

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