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ECO-DESIGN IN THE PORTUGUESE PACKAGING INDUSTRY

JOÃO PEDRO CAMPOS MONTEIRO
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Dissertation presented to the Higher Institute of Engineering of Porto in order to fulfil the necessary requirements to obtain the Master's Degree in Mechanical Engineering – Industrial Management, conducted under the guidance of Doctor Francisco José Gomes da Silva from the Department of Mechanical Engineering of School of Engineering, Polytechnic of Porto, and co-supervised by Doctor Sandra Cristina Faria Ramos, from the School of Engineering, Polytechnic of Porto.

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KEYWORDS

Eco-design; Packaging; Sustainability; Industry; Environment; Manufacturers

ABSTRACT

According to “The 2030 Agenda for Sustainable Development” of United Nations where 17 goals for the Sustainable Development are established, one goal has direct implication for the industrial sector – assure sustainable consumption and production patterns.

In a world where globalization is more and more present, packaging emerges as a link between all points around the world allowing to transport and commercialize products on a global level.

Therefore, it is necessary to study how is the Portuguese packaging industry adapting itself to the increasing demands of the markets, while complying with the global environmental requirements.

Accordingly, in this study, this industry will be precisely analysed, intending to understand how the theme of Eco-design and sustainability on the industrial processes are faced by the companies.

A characterization of the industry is intended to be done, defining how companies should organize and prepare themselves in order to have a diminishing environmental impact, a raw-materials sustainability policy and implement environmental aspects through the packaging’s life cycle – Eco-design.

PALAVRAS CHAVE

Eco-design; Embalagem; Sustentabilidade; Indústria; Ambiente

RESUMO

De acordo com "The 2030 Agenda for Sustainable Development" das Nações Unidas onde são definidos os 17 objetivos para o Desenvolvimento Sustentável, é apontado um objetivo com implicação direta para o sector industrial – assegurar um consumo e padrões de produção sustentáveis.

Num mundo onde a globalização é uma realidade cada vez mais presente, a embalagem surge como um elo de ligação entre todos os pontos do globo permitindo o transporte e a comercialização de produtos a nível global.

Torna-se assim essencial estudar como a indústria da embalagem portuguesa se está a adaptar às cada vez maiores necessidades do mercado, cumprindo com as exigências ambientais globais.

Assim, neste estudo, será analisada ao pormenor esta indústria, pretendendo-se perceber de que modo é encarado o tema do Eco-design e sustentabilidade nos processos industriais e socioeconómicos das diversas empresas.

Pretende-se caracterizar a indústria, definindo de que modo as empresas se deverão organizar e preparar para que tenham um cada vez menor impacto ambiental, uma política de sustentabilidade de matérias-primas e a implementação de aspetos ambientais ao longo do ciclo de vida das embalagens por elas produzidas – Eco-design.

LIST OF SYMBOLS AND ACRONYMS

Acronyms List

AEP	*Associação Empresarial de Portugal*
AIVE	*Associação dos Industriais de Vidro de Embalagem*
APIGRAF	*Associação Portuguesa das Indústrias Gráficas e Transformadoras do Papel*
APIP	*Associação Portuguesa da Indústria de Plástico*
ASTM	American Society for Testing and Materials
DfE	Design-for-the-Environment
EAA	European Environment Agency
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management Systems
EU	European Union
FEFCO	European Federation of Corrugated Board Manufacturers
FILMET	*Fileira Metal*
GDP	Gross Domestic Product
HDPE	High-Density Polyethylene
IBCs	Intermediate Bulk Containers
INE	*Instituto Nacional de Estatística*
ISO	International Organization for Standardization
KPIs	Key Performance Indicators
PE	Plastics Europe – Association of Plastics Manufacturers
PET	Polyethylene Terephthalate
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride
R&D	Research and Development
UN	United Nations
USA	United States of America

Units List

dl	Decilitre
g	Gram
kg	Kilogram
l	Litre

Symbols List

%	Percentage
CO_2	Carbon dioxide

SO_2	Sulphur dioxide
NO_x	Nitrogen oxides

GLOSSARY OF TERMS

Population	Results under investigation.
Sample	Subgroup of the population.
Eco-Management and Audit Scheme (EMAS)	Voluntary environmental management instrument developed by the European Commission which promotes the continuous improvement of the environmental performance of organizations.
Environmental aspect	Any element of an organization's activities, products or services that interact with the environment.
Environmental impact	Refers to any change in the environment, adverse or beneficial, that results partially or completely of an organization's activity, products or services.
Sustainability	Human actions and activities that aim to assure current human needs without compromising the futures generations' needs.
Lead Time	The time between the placement of an order and its delivery.

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INTRODUCTION

1 INTRODUCTION

1.1 Contextualization

The Packaging Industry has been growing according to the human needs. In fact, the desire to keep food products in containers safe from animals and contaminants started to push entrepreneurs to find solutions, first using materials easily available on nature and afterwards using more complex materials, that also allowed to handle, transport and keep for long periods of time the products.

These solutions played an important role in ancient wars, as they allowed keep troops well-nourished and strong on the field, playing a key role for the success of troops such as the army of Napoleon Bonaparte. The success of packaging in keeping food products was replicated for other products such as medicines and cosmetics with great results.

Subsequently, with the unbridled consumerism of the world society, the packaging started to be used in every single product, making the packaging industry struggle to face the worlds' demand.

Consequently, packaging manufacturers in Portugal and all over the world have developed their companies to face this demand by any means, sometimes even damaging the ecosystem where they are integrated into and not assuring the sustainability of raw materials used in production.

All packages during their life cycle have environmental impacts since raw materials extraction and production to the usage and disposal. These environmental impacts are a result of the decisions taken through the various stages of the products' life cycle.

Therefore, to accomplish the increasing demand for packages in the modern society, it is important to introduce environmental aspects in the equation, in order to minimize the environmental impacts and having a more sustainable development.

The challenging of turning packaging more ecological should be taken by companies and consumers, as the project phase and commercial facilities are the stages where the main decisions related to environmental impacts are taken.

To prepare a strategy to integrate environmental aspects in the process of packaging design, the complexity and the diversity of packages and the knowledge evolutions in the design domain should be taken into consideration.

So, Eco-design appears as a new approach to the process of packaging design, having a special emphasis on the environmental impacts through the life cycle of a pack, in order to have a more efficient production with less pollution.

In this project, the introduction of eco-design and ecologically sustainable practices in the Portuguese packaging industries are evaluated. At the same time, the study evaluates the importance that environmental aspects have for the companies and if they are prepared for the challenge of adapting their packages in order to reduce environmental impacts.

1.2 Objectives

This project has as the main goal to analyse the implementation and development of eco-design in the Portuguese packaging industry and the sustainable practices applied in the packaging production in order to evaluate the environmental commitment of this industry.

It is also a goal of this study to understand how some variables such as education of employees, business volume of the company and purchasing decisions factors are somehow statistically correlated to the environmental mind-set present in the company.

1.3 The methodology used in the development of the dissertation

To develop this study a special methodology was adopted so that the proposed objectives could be achieved. This process was done according to the following steps:

- Bibliographic research;
- Packaging industrial associations research:
- Identify Portuguese packaging companies;
- Questionnaire elaboration that allowed to get across analysis, intending to evaluate the congruence of the answers;
- Validation of the questionnaire by Institutions and important companies;
- Distribution of the questionnaires trough packaging manufacturers, collecting and analysis of the answers;
- Statistical data processing;
- Critical analysis of results;
- Elaboration of conclusions;
- Writing of the present dissertation.

1.4 Structure of the dissertation

This dissertation is composed of six chapters connected between them in order to make it easily readable and understandable by all readers. There are four main chapters where the study development is presented and there two support chapters that include the bibliography and other sources of information, and appendices.

The main chapters begin with the introductory chapter, where the contextualization and objectives of the study are presented, and the path to achieving them.

In the second chapter, the background is developed going into the technical characteristics of packaging and its importance for humanity over the years. In this chapter are also presented some important environmental preservation concepts for this research such us Eco-Design and Recycling. The chapter is finished after presenting the Survey and Data processing.

The development of the study is presented in the third chapter, presenting the questionnaire structure and validation, and the results of the survey. Recommendations for the Portuguese packaging industry are suggested on the final of this chapter.

In the fourth chapter, the conclusions of the research are presented with proposals of future studies.

BACKGROUND

2 BACKGROUND

This section aims to explore the packaging industry while evaluating the importance of this market for the Portuguese economy and how are the Portuguese companies reacting to the environmental global challenges.

In fact, it intends to describe the history of the packaging industry, the main characteristics that should be accomplished by it and the importance of the packaging for the development of humanity.

As this research emphasizes the eco-design and the good practices in packaging development are also presented in this section some important concepts regarding environmental preservation.

Being the key collector of data for the investigation of a survey, some techniques for its formulation and analysis are also presented and developed in this section.

2.1 The Packages

According to the Portuguese legislation (Decreto-Lei nº 366-A/97), “packages” are all products made of any material that aims to keep, protect, move, handle, deliver and present commodities, as raw materials or finished-goods, from producer to user or consumer, including all disposable parts.

Despite this definition being more than 20 years old and the packaging has changed a lot its appearance and features in the last years, it is still much updated. Indeed, this definition would suit all the packages since its first appearance.

The first record of packages is from 10,000 B.C. when the nomad tribes migrated to other places and needed to keep, protect and transport food and fresh water (Emblem, 2012). Therefore, packaging has begun with natural and easy to get materials, such as leaves, wood, shells and leather.

One of the first examples of the usage of "packaging" by native tribes was the usage of leaves to wrap meat as the source of the next meal was unknown and resources needed to be kept fresh.

With the development of the tribes, nomads learnt how to farm the land and started to settle and establish small communities. The crops from the farms needed to be

maintained fresh and protected from animals and it was also essential to store the food handily.

In fact, according to Emblem (2012), some evidence dating to 8000 BC show that clay pots and large wide-mouthed jars were used for grains, salt, olives and oils.

What allowed this was the discovery that sand could be fused at high temperature and shaped into different types of recipients, what made possible the storage of liquids. Endler (2003) points out that those rustic containers were used also for perfumes and cosmetic products in Mesopotamia.

The exploration spirit and the trading ambitions lead to the development of the trading between cities, countries and even continents what made crafters even more skilled. With the intensification of the transactions arises the necessity to protect the goods, avoiding losses and contaminations (Endler, 2003). That's when wooden barrels and casks appear, while sealed containers are getting launched too and used to display the goods in the local markets.

Thus the concept of using packaging as a convenient mean of transporting products, to protect them and allow the display of them at markets was established, although this was at a bulk level, not taking in consideration to make it appealing to the consumer (Emblem, 2012).

Until the modern age, there weren't any great advances in the packaging development, but innovative technologies were developed due to maritime expansion.

The pharmaceutical industry began to use labelled glass flasks sealed with wax, and by 1740 medicines were sold this way all over Europe, being the pioneer industry in using packaging to consumption (Lautenschlager, 2001).

Nowadays, several raw materials are used to produce packages, and according to a classification presented by Evangelista (1994), these materials can be from animal origin, plant origin, mineral or synthetic.

Consequently, Mariano and Froemiming (2008) identify three different distinct phases in the packaging history, according to the raw materials origin:

- **1st Phase** – Until 4000 BC – Usage of natural packaging;
- **2nd Phase** – Until 1760 AC – Abundance of craft packaging made of clay, glass and fibres;
- **3rd Phase** – Until current day – Industrial packaging.

As fresh provisions were a competitive advantage in the battles, the 3rd phase begun with the incentive of Napoleon Bonaparte to the development of a package that could preserve the food in order to feed all French soldiers in the field of battle.

Therefore, Nicoles Apert, a French backer, started to preserve food in glass flasks, by the introduction of the hermetic sealing, in 1795.

In 1810, Peter Duran, a French living in the United Kingdom, gets the patent from King George III to produce canned food using the Apert's technique and the steel can appears.

From 1810 onwards, there was a huge development the tins industry, and canned sardines started to be produced in Nantes, France, by Joseph Pierre Colin considered until now the founder of the Conservation Industry.

The major influence in moving the packaging from bulk level to addressing the individual's needs was the Industrial Revolution (Emblem, 2012). The start of mass production brought large-scale migration of workers and their families to cities, and foods previously produced and readily available at home now had to be transported to the cities.

According to Calver (2004), the packaging industry emerged in the 19th century as new technologies enabled manufacturers and growers to supply their products to stores in pre-packed formats, allowing them to harvest their products, can them while fresh and transport them to the market.

Endler (2003) emphasises two great innovations that allowed this growth in the industry – the usage of cellulose and the discovery of all plastics which allowed to pack any kind of products.

This huge change in the patterns of consumption increased the demand for packaging – barrels, boxes and bags – leading the packaging industry to a scale that hadn't previously been seen.

In fact, the modern age in the packaging industry is characterized by the technical requirements. At the end of the 19th century, the consumers started to become more demanding about the quality and the safety of the products, so governmental laws started to appear to establish standards that would face markets' requirements.

Despite all these developments, big challenges continued to be faced by the packaging industry.

In the 40's the firsts supermarkets opened, and the packaging began to play a key role in the marketing mix. The shape, the colour, the aesthetic and the usability of the packaging were vital to determinate the success or the failure of a product (Endler, 2003) as the packages started to be used as a competitive edge to compete with other products and appeal to costumers' attention (Mariano, 2008).

In the early days, packaging's role was essentially utilitarian (Calver,2004), and over time it was developed according to human needs. First packages satisfied the need to keep, transport and store goods. Afterwards, the need to protect and preserve foods was raised, and the packaging industry implemented innovative technologies.

With the Industrial and Commercial revolution, the marketing role started to be absorbed by the packaging creating more and more competitive products.

This fact was highlight by Robert Opie in the *Packaging Source Book* (1989): "The basic functions of the sealed package – to protect the product, to enhance its appearance and to facilitate its distribution" and he continues pointing out the effect that the appearance had on retailing.

In fact, nowadays packaging plays a significant role in a product being a key point for the success of a product, so nowadays packaging is seen as a marketing tool (James Pilditch, 1973).

With the increasing use of packaging as a marketing tool, other authors emphasize this aspect in their packaging definitions.

ABRE (2012) mentions that packages present a wide variety of shapes, models and materials, and are part of our daily life in diverse ways, some easily recognized, others in a subtle way, all, however, provide benefits that justify their existence. The product and the packaging are so connected that may not be considered one without the other.

Products cannot be planned separately of the packaging, that on its turn, should be designed based on engineering, marketing, communication, legislation, economy and innovation. (ABRE, 2012).

2.1.1 Types of Packaging

There are distinct levels of packaging: primary, secondary and tertiary (Decreto-Lei nº 366-A/97). These types are defined according to the role of the packaging in the path between manufacturing and final consumer:

- **Primary packaging or sales package** – incorporates any kind of packaging developed in a way that allows constituting a sales unit for the final consumer or to a consumer in the point of purchase;

- **Secondary packaging or grouped packaging** – includes all packages developed to constitute, in the point of purchase, a groupage of a certain number of sales units, whether they are sold to the user or final consumer as such or serve only as a replenishment mean of the point of sale. This kind of packaging can be removed from the product without affecting its characteristics;

- **Tertiary Packaging or transport packaging** – includes all packages conceived to facilitate the handling and the transport of a batch of sales units or grouped packaging, in order to avoid physical damages during the cargo handling and

transport. The transport packaging does not include the containers used for road, rail, sea or air transport.

In all these levels of packaging different materials are used to accomplish the needs of each product. The usage of a material instead of another depends not only but also on the needed technical characteristics.

2.1.2 Needed Technical Characteristics

Packages as any other product should be designed according to some requirements. These requirements may include marketing or consumer-based needs such a shape or colours usage but first, there are some technical characteristics that must be achieved.

As previously mentioned, the Portuguese legislation states that packages aim to keep, protect, move, handle, deliver and present products, so these are the main inputs that should be taken into consideration while designing a new packaging.

In fact, a packaging only exists if there's a product to carry in it, so it should be centred in the item. Physical characteristics of the product such us weight, volume, recommended temperature, shape, type of material, shelf life, among others should be taken into consideration to determinate the size of a package, the materials that should be used, the thickness, the humidity absorption, the possible contact with air, load capability, and many other varieties.

According to international laws, there are only official technical requirements for:

- Pharmaceutical products;
- Foods;
- Medical materials and devices;
- Dangerous goods.

For all other products, companies can define their own requirements in order to keep products safe from manufacturers to consumers, although there could exist some limitations to the use of certain materials according to the law of each country.

Pharmaceutical products

Pharmaceutical packaging has important regulations with some variations from country to country, but there some common aspects that must be accomplished such us the assurance of the efficacy of the drug through the intended shelf life, control of possible packaging components into the drug, prevention of microbial contamination and sterility. ISO 15378 can be highlighted as the main international standard that includes the principles of good practices for primary packaging for medicinal products.

Foods

Food packaging is critical to maintaining food safety and public health. Therefore, there are some important organizations all over the world that aim to legislate and control how food is produced and how it is transported from producers to consumers, such as the US Food and Drug Administration and the European Food Safety Authority. Both authorities have laws and requirements that must be achieved by packaging manufactures in order to allow the commercialization of foods in their region. There are also some international standards, like ISO 22000, that are used worldwide to guarantee the food safety.

Medical materials and devices

As medical materials and devices are sensitive products, the packages must accomplish restrict standards developed by ASTM (ASTM F1585, ASTM F2097) and ISO (ISO 11607). These packages are often tested in order to check its accordance with international standards.

Dangerous goods

The packaging of dangerous or hazardous products is highly regulated. Standard such us ASTM D4919, ISO 16104 and UN Recommendations on the transport of Dangerous Goods should be taken into consideration when developing a package for this kind of products.

2.1.3 Materials Used in Packaging

According to Emblem (2012), today's global packaging industry is roughly divided into 36% paper and board, 34% plastics, 17% metals (steel and aluminium), and 10% glass, the remainder being made up of materials such as wood and textiles.

These raw materials can define the technology, the costs, the marketing and the final use, among others, so it is important to understand some of their physical and economic characteristics (ABRE,2012).

Glass

From all major materials, glass is probably the oldest used as a packaging medium. It started to be used about 1500 BC, and the first packages made of it were simple hollow vessels (Emblem, 2012). Around the first century, BC glass blowing started to be developed what allowed make glass containers in a wide range of shapes, sizes and colours, in great quantities at a lower price.

This versatility allied to the capacity of glass containers to keep the products flavours, prevent the gas exchanges, being washable and reusable made flasks being continued

used in diverse market sectors such as beverages (figure 1), perfumes and pharmaceuticals.

In fact, glass stands as an important packaging material as studies have shown that in the mind of today's consumer it is associated with features such as cleanliness, inertness and high clarity (Emblem, 2012).

On the major advantages of the glass is that it is 100% recyclable and in it can be recycled endlessly without losing its quality and purity, allowing to save the usage of raw materials, reduce the energy consumption, the CO_2 emissions and the amount of waste on landfills (CERV, n.d).

Figure 1 - Glass bottle used by a Portuguese beverages company.

Metal

The metal packaging was first developed to face food needs of Napoleon's army while food sterilisation systems started to be introduced in processes such us canning (Rodrigues et al., 2010).

Steel was the first metal to be used as packaging material, and it continues to be used for heat-sterilised cans for food and drinks. Aluminium was introduced in the 50s and nowadays it plays a key role mainly for canning carbonated sodas (Emblem, 2012).

Pereira (2006) mentions that steel, tinplate and aluminium are used for cans, containers, trays and aerosols. Steel is also used for manufacturing large containers such as drums and intermediate bulk containers (IBCs) (Emblem, 2012).

According to the European Aluminium Association (2016), Europeans use up to 50 billion cans every year only for beverages. What makes it an iconic pack for drinks is that a can retains taste while offering a very long shelf life, and it is extremely light, stackable, virtually unbreakable and with a great temperature conductivity, which allows drinks to be cooled very quickly (figure 2).

Metal packaging is also infinitely recyclable, being a great solution for achieving EU's recycling targets for 2025 and 2030. Recycling aluminium saves up to 95% energy of primary production, making a major contribution to sustainability.

Figure 2 - Aluminium can used to pack carbonated soda.

Plastics

Plastics are not just one material. In fact, there are hundreds of different plastics with a wide variety of properties, designed to meet the needs of every single application (Plastics Europe, 2018).

The first plastics appeared in the 19th century, but major developments in the plastics packaging industry were only taken since the 1940s. From that moment on, plastics have been growing in utilisation, more than any other packaging material, mainly due to the discovery of low-cost production processes and to the versatility and adaptability of plastics characteristics (Emblem, 2012).

Currently, according to the latest data from PE, most plastic materials are derived from fossil feedstock such as natural gas, oil or coal, but they can also be bio-based. Despite the massive number of different plastics, they are all organic and are divided into two great groups according to their physical and chemical characteristics: Thermoplastics and Thermosets (figure 3).

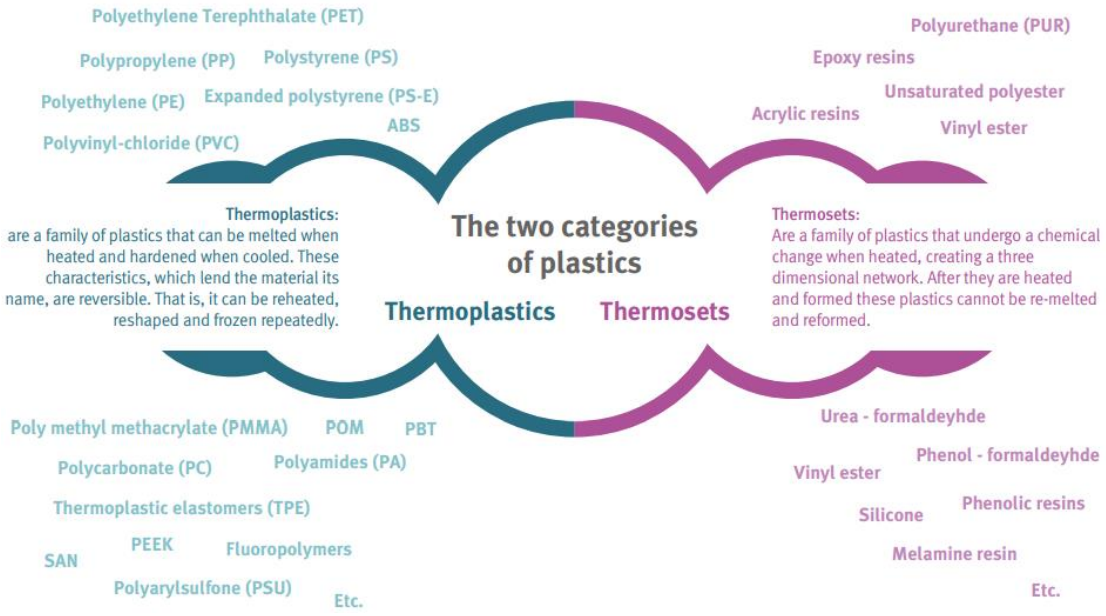

Figure 3 - The two categories of plastics – Thermoplastics and Thermosets. Source: Plastics Europe (2017).

Emblem (2012) mentions that plastics have replaced more traditional materials such as glass and metal in some applications, such as:

- The change from glass to polyethylene terephthalate (PET) containers for bottled water and soft drinks;
- The change from glass to high-density polyethylene (HDPE) containers for milk (figure 4);

The change from metal can to flexible plastics bags for pet food, soups and sauces.

Figure 4 - Change from glass (left) to HDPE containers (right) for milk.

Plastics above all allowed manufacturers to reduce the total costs of the packed product and be more competitive, as plastic containers have become lighter, less voluminous and more resistant than traditional materials. These characteristics help not only the reduction of total costs but also to the reduction of the environmental impact, as less raw materials are consumed, and less waste is produced (PLASTVAL, 2008).

Although all these advantages, plastic packaging was not completely adopted by manufactures. Some notable brands of bottled water retain the glass for its high-quality image, and most of the canned food companies kept the traditional can (Emblem, 2012).

Plastics are also a fundamental component for the reel-formed “carton” typified by the Tetra Pak (figure 5) and SIG Combibloc containers. Indeed, these packages are primarily built of paperboard, but they rely on plastic layers as heat sealing and the barrier to humidity and gases (often along with aluminium foil). This type of container has a dominant position in the fruit juice and milk sectors, mainly because of its lightweight and regular-shape (Emblem, 2012).

Figure 5 - Tetra Pack package used for fruit juice.

As reported by Pereira (2006), the most used plastics for packaging are:

- Polypropylene (PP);
- Polystyrene (PS);
- Polyvinyl chloride (PVC);
- Polyethylene terephthalate (PET);
- High-density polyethylene (HDPE).

Paper

As is widely known, paper and board are the most used materials in today's packaging. In fact, it is thought that papermaking started in China in the second century AD, spread throughout the world and remained a relatively small-scale, artisan activity until paper production became industrialised during the nineteenth century (FEFCO, 2018).

Machinery progresses made possible to build up layers of cellulose fibre into a continuous web, allowing obtain a wide range of materials with different thickness and performance (Emblem, 2012).

Thanks to its basic raw materials, and despite considerable changes, the modern corrugated packaging is not so different from that produced and used decades ago. This ingenious construction will always provide a very wide range of benefits and is and will remain popular, up-to-date and innovative (FEFCO, 2018).

The most important package in the world is the workhorse of secondary packaging: the corrugated board box (figure 6).

Figure 6 - Corrugated board box.

Paper and board are 100% biodegradable and recyclable.

Wood

Wood has been used as a packaging material since ancient times as it was easy to get from nature. Nowadays, it plays a crucial role in moving goods from manufacturer to seller in the form of a pallet (Emblem, 2012).

However, the wood packaging is also important for transport heavy engineering parts and is used as the main material for barrels or boxes for fresh products. It may improve the quality of wines stored in barrels (figure 7), being fundamental for the taste and ageing (Pereira, 2006).

Figure 7 - Wood barrels used to transport and keep Port Wine.

Other Materials

Apart from traditional materials, there's a wide range of materials that are used in small quantities for packaging purposes such as cork (figure 8) and textiles.

Figure 8 - Cork stoppers for wine bottles.

2.1.4 Packaging Market

The packaging industry represents a large share in the Portuguese gross domestic product (GDP). According to Monteiro (2016), it represented between 3% and 4% in 2016, twice the world average (1,5%).

According to the latest data of Statistics Portugal (INE, 2018), there are 641 packaging manufacturers in Portugal (2016), divided into five groups, as can be seen in table 1. These packaging producers represented a total volume of sales of more than two thousand million, making this one of the most important industries in the country.

Table 1 - Number of packaging manufactures in Portugal in 2016. Source: INE (adapted).

Type of Packaging	Number of Manufacturers	Sales
Wood	144	132 018 618 €
Paper and Corrugated	249	793 426 355 €
Plastic	158	482 257 611 €
Glass	4	533 978 953 €
Metal	86	216 562 206 €
Total [2016]	**641**	**2 158 243 743 €**

As reported by Gonçalves (2017), the packaging market has grown by 3.2 % in 2016 in Portugal, although the number of manufacturers has been decreasing over the years, mainly in plastics.

In 2014, Portuguese packaging manufacturers produced a total of one million and six hundred thousand tons of packages of all kind materials.

As stated by Monteiro (2016) stats, the leading material in production (weight analysis), is paper and board (45%) followed by the glass (25%), and polymers (24%).

The Portuguese packaging industry is known for the manufacturing of premium products that aim mainly to the international exportation, being the also leader in contract packaging schemes. National manufacturers are also worldwide recognised by the cork packaging mostly for the wine industry.

Despite still having a long path onwards for achieving ecological sustainability, Portuguese packaging manufacturers have been showing environmental awareness by focusing on design innovation and weight reduction, mainly in glass packaging.

Regarding recycling rates, in 2014 Portugal registered 72% for paper and board, 98% for wood, 76 % for metals and 55% for glass. When it comes to plastics the recycling rate is lower than 40%, showing a huge margin of progress. In fact, as can be seen in figure 9, in 2016, more than 35% of the plastics ended up on landfills, what represents a severe impact for the environment.

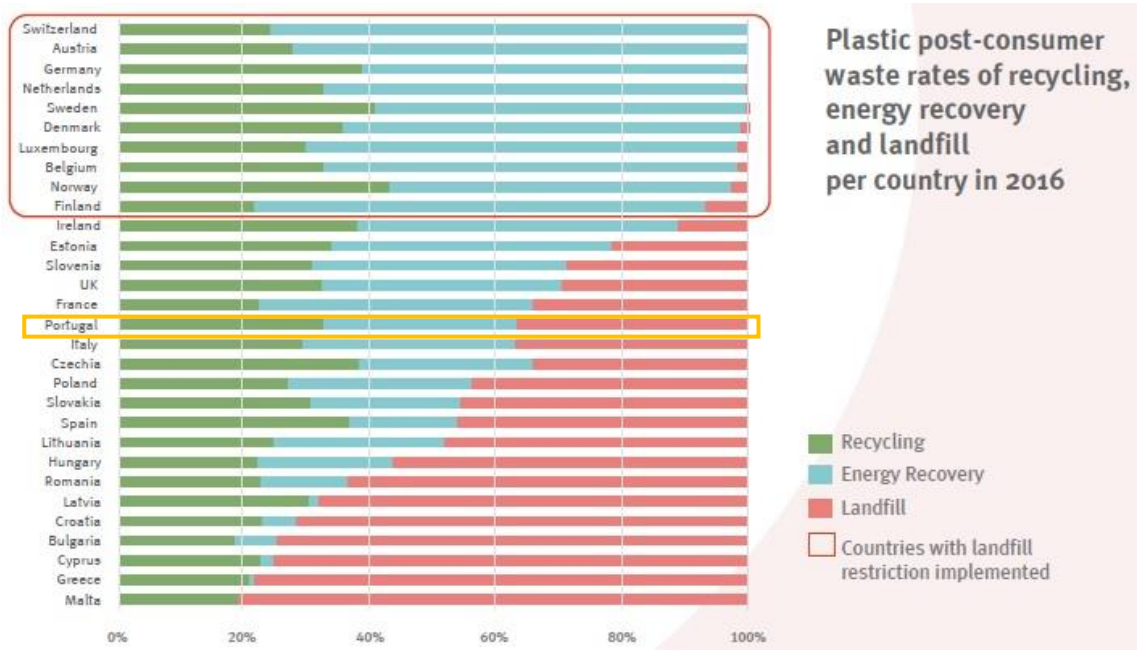

Figure 9 - Plastic post-consumer waste rates of recycling, energy recovery and landfill per European country in 2016. Source: Plastic Europe (2017).

In global terms, the packaging industry is showing good future scenarios, as according to a report by Smithers Pira, where an analysis is made for the period 2015-2020, this industry is expected to grow by an annual average of 3.5%.

In 2020, it is expected that the global packaging industry achieves a business volume of 998 billion dollars.

2.1.5 Packaging Industrial Associations

In Portugal, there is not a Packaging Association that represents all packaging manufacturers and representatives or that embraces all kind of packaging materials. In fact, there are several industry associations that are divided according to packaging material and final usage of the package.

As there are numerous industry associations, only the most representatives in a number of affiliates and business volume are going to be presented:

APIGRAF – Associação Portuguesa das Indústrias Gráficas e Transformadoras do Papel

Figure 10 - APIGRAF institutional image.

APIGRAF (figure 10) was founded in 1974 and represents 2,700 Portuguese companies that have as core business paper and board items. Therefore, this association represents not only packaging manufacturers but also newspapers, books and posters producers, among others.

The members of this association are responsible for more than 26,000 jobs and together represent a business volume of 2.5 thousand million euros.

AIVE – Associação dos Industriais de Vidro de Embalagem

Figure 11 - AIVE institutional image.

Founded in 1975, this association (figure 11) dedicates exclusively to the promotion of glass packaging manufacturers and represents 100% of glass packaging production in Portugal.

Currently, 4 companies are represented by AIVE and these are responsible for 6 production plants, 15,000 ktons per year and 2,000 direct jobs.

In the last 10 years, AIVE has focused its activity on environmental issues, having established some partnerships in order to achieve innovative and sustainable solutions together with all associates.

APIP – Associação Portuguesa da Indústria de Plástico

Figure 12 - APIP institutional image.

The Portuguese Plastic Industry Association (figure 12) is a non-profit association that has as goals the promotion and the support the plastic industry as well as represent the sector in governmental subjects, national entities and international organisations.

APIP was founded in 1975 and nowadays is constituted by 130 members that are responsible for 60% of plastics production in Portugal and for 10,000 workers.

These manufacturers are distributed for different markets, where packing production and technical, industrial and automotive components can be highlighted.

AFCAL – Associação dos Fabricantes de Embalagens de Cartão para Alimentos Líquidos

Figure 13 - AFCAL institutional image.

This association (figure 13) was founded in 1996 and plays a key role in representing the manufacturers of liquid-food cartoon packaging, developing its activity only for 2 major groups – SIG Combibloc and Tetra Pak.

Despite having only 2 groups as associates, these represent almost 100% share in the market.

AFCAL has also set as a mission the collection and sorting of all packages made by the members in order to recycle all of them.

FILMET – Fileira Metal

FILMET (figure 14) was founded in 1996 and is the association responsible for metal packaging manufactures in Portugal. In fact, it was created to have an active participation in the integrated system of packaging waste management, but nowadays it develops its activity in other areas, such as the promotion of metal packaging materials and research & development.

Figure 14 - FILMET institutional image.

It represents four packaging manufactures present in Portugal but also metal packaging importers.

2.2 Environmental Preservation Concepts

To understand how it is possible to improve the environmental performance of an organization and its products it is crucial to master some environmental preservation concepts such us:

- Eco-design;
- Recycle;
- Reuse.

2.2.1 Concept of Eco-design

Eco-design has as origin the junction of two words: Eco, from Greek origin, meaning home, and being used several times to define environment; Design, from the Anglo-Saxon origin, meaning industrial project of a product or related to beauty and elegance aspects. In the USA another equivalent word is used but it was the same meaning and aiming – Design-for-the-Environment (DfE).

It is the systematic integration of environmental considerations in the process of product design (Rocha, 2011).

In fact, the International Organization for Standardization goes deeper defining Eco-design in the ISO 14006:2011 as “the integration of environmental aspects into product design and development, with the aim of reducing adverse environmental impacts throughout a product's lifecycle.”.

This means that eco-design should be faced as a proactive approach embedded in a company operations and strategies, aiming to continuously improve the environmental performances of packages considering their whole life cycle from raw material to end of life, while other requirements are taken into consideration, such as functionality, cost and production (Yeang and Woo, 2010).

Every packaging has environmental impacts, that may occur in any phase of the package life’s cycle – raw material extraction, manufacturing, transport, usage and disposal (or recycling). These environmental impacts may vary in the size of the consequences, in the time that the effects are felt and in the size of the affected area.

To effectively avoid the possible ecological consequences through the products’ life cycle, it’s crucial to integrate environmental considerations since the beginning of the packaging development.

According to Rocha (2011), it is thought that more than 80% of environmental impacts related to a product are stipulated during the design phase. This is why eco-design is so important for the sustainable and ecological success of a product.

Governmental institutions, as well as customers, are increasingly pushing companies to reduce the environmental impacts of the products developed by them, mainly related to the consumption of materials, energy and water, the waste and emissions.

Actually, companies can take numerous benefits with the introduction of eco-design in their development processes, not only the fulfilment of legal requisites but also the reduction of production costs, the better quality of the packages, the promotion of innovation and the advantages of the eco-friendly image passed to society.

Therefore, it takes into consideration social, economic and environmental impacts during the lifecycle of a product or service (figure 15).

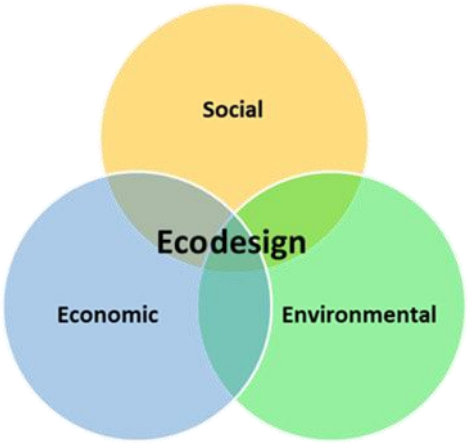

Figure 15 - Elements integration for Eco-design.

Consequently, eco-design is needed for competitiveness in a sustainable society and therefore should be part of a company's strategy in the short and long-term.

Even though the ecological design started to be developed in the 70's, Rocha (2011) points out some barriers that hinder its implantation:

- Lack of education in environmental aspects and eco-design;
- Deficiency on the perception of the environmental impact of a package by manufacturers and customers;
- The belief that eco-design needs a strong monetary investment and an increase in production costs and labour force;
- Change resistance to consumption patterns, and technical difficulties in the adaption to new realities.

To better understand how manufacturers may take benefits from the introduction of eco-design on the development process of a packaging it is crucial to understand the environmental aspects (consumption of materials and energy) and environmental impacts (climate changes, toxicity, air, water and soil pollution, among others) that may occur through the package life's cycle.

An integrated approach of the environmental aspects and impacts should be done in partnership with all elements throughout the value chain: suppliers, logistics providers, retailers and waste managers.

According to G.EN.ESI (2014), adopting a lifecycle perspective and mapping the environmental impacts related to each lifecycle phase (also known as a life cycle assessment or LCA) is important to identify unexpected impacts that may exist. There are some tools that facilitate this analysis but if the product is too complex or periodic analysis are carried out it is recommendable the usage of a software to do it.

The relative contributions of each life cycle phase will also help you prioritise your efforts, and help you monitor the transfer of impacts from one life cycle phase to another (figure 16).

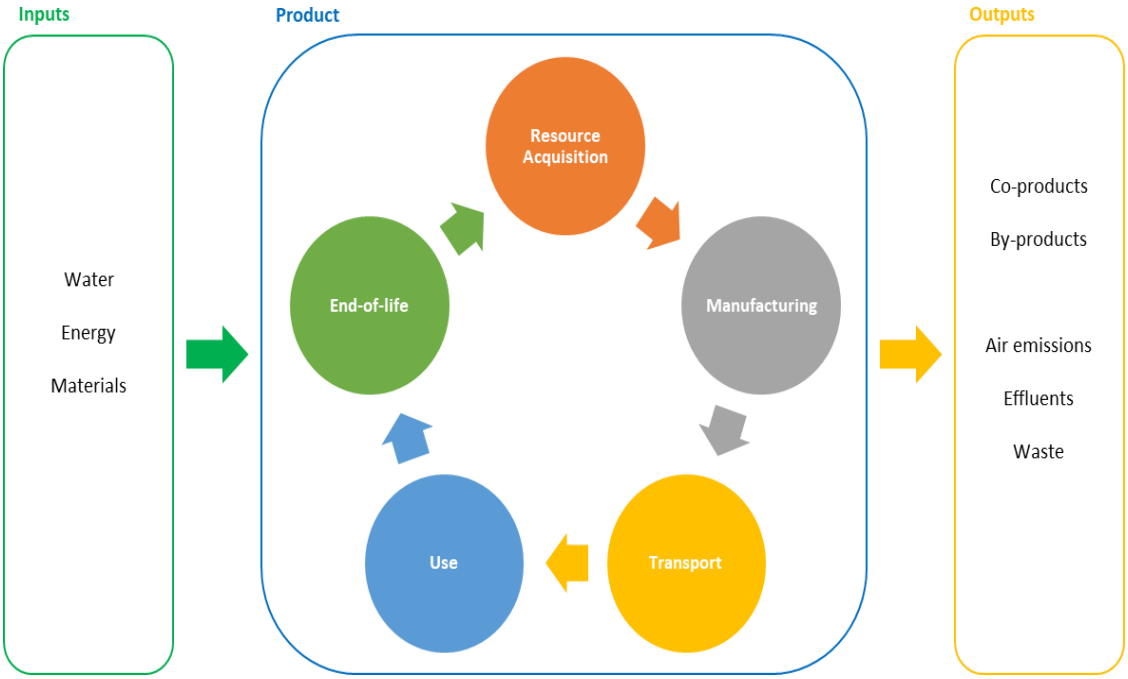

Figure 16 - Product's Life Cycle. Source: G.EN.ESI (2014) (adapted).

This approach aims to ensure that every environmental characteristic of a product is considered and that the environmental impacts are not transferred from one life cycle's phase to another, neither transferred from on affected area to another, trying to find a balance that minimizes the global impact of a product.

As stated by Vieira *et al.* (2013) in "*Manual Prático de Ecodesign*", the Eco-design can be introduced in a company without changing the traditional development process of a product. Apart from usual requirements, a new approach should take into consideration environmental aspects as can be seen in the figure 17.

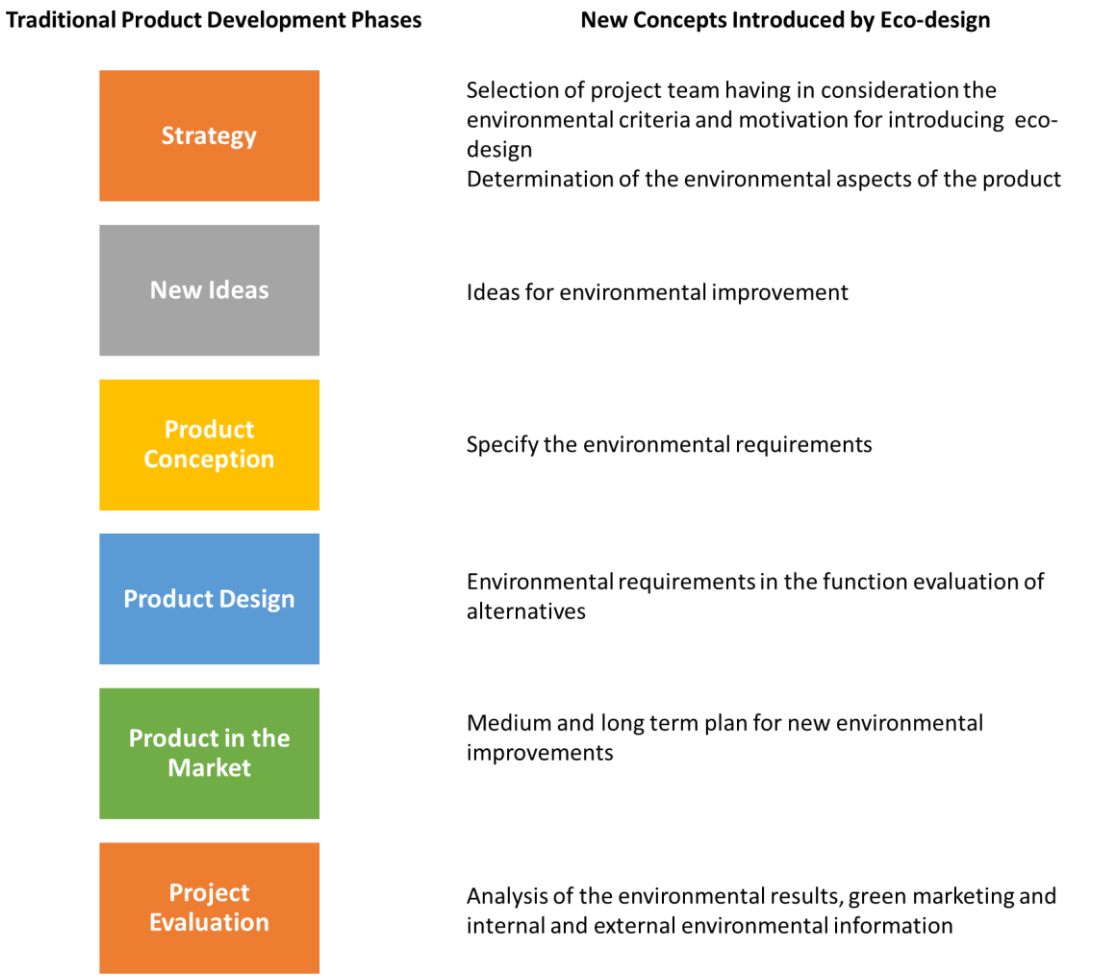

Figure 17 - New Concepts Introduced by Eco-design in the Traditional Product Development Phases. Source: Vieira et All (2013) (adapted).

Although there are many motivating factors to the introduction of Eco-design, it is still a philosophy very are to introduce in some companies, mainly, as stated before, due to the lack of information.

Therefore, the ISO created an international standard so that companies could have a guide to accomplish their sustainable motivations on product design and be recognized by it with a certification. The standard that contemplates the Eco-design in an environmental management system is the ISO 14006.

Indeed, it can be seen as an evolution of ISO 14001 (figure 18) with the introduction of Eco-design. Consequently, comparisons can be made between them, with special focus to the inclusion of Eco-design and product development under the scope of the environmental management system, as it has a great influence in the environmental impact of the products (Boucher *et al.* 2017). ISO 14006 also forces companies to have continuous improvements in the environmental performance and to give enough training to product developers and designer in order to assure that Eco-design is established and acknowledged by them.

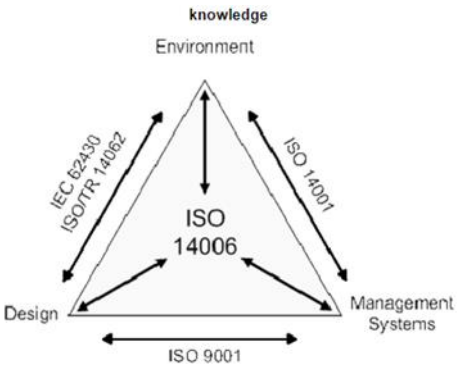

Figure 18 - Origin of ISO 14006 and its relation with other standards. Source: ISO (2011).

2.2.2 Concept of Recycling

Recycling appears as an important option for waste management, as it is the process of collecting materials that otherwise would be thrown away as trash and turning them into new useful products. Actually, recycling can prevent the waste of potentially useful materials and reduce the consumption of fresh raw materials and thereby reducing the environmental impacts such as energy usage, air pollution and industrial wastewater.

Kirwan (2018) defines recycling as the reprocessing of a material in a production process aiming the original purpose or another one, meaning that recycled materials can and should be used in any application that requires them, not being stuck to its original purpose.

Although there are diverse factors that influence the success of recycling, Gil (1990) points out some issues that should be taken into consideration, based on the worldwide experiences:

- Identification and analysis of the markets for recycled products;
- Cooperation with local authorities;
- Chosen recycling place so that the transport and the maintenance can be minimized;
- Analysis of the economic feasibility of the recycling company, including the social benefits, allowing gains compared to other alternative processes.

In fact, this author not only points out the success factors that lead to a sustainable recycling process but also states the two main benefits of it:

- Reduction of waste volume;
- Savings on energy and raw materials.

Despite being a process that might not be cheap, it origins the return on investment with the materials produced, and with the savings related to landfills sites and the social benefits obtained.

Almost all packaging materials can be recycled more than once, but in spite of this capability, it is crucial to evaluate the environmental impacts of recycling through the products' life cycle. In some occasions, it is possible that producing with fresh raw materials is cheaper and less harmful for the environment than recycling (Karaski, Ribeiro, Pereira and Arteaga, 2016).

In these cases, it is important the consciousness for reducing the need for a packaging, trying to find more ecological solutions, or learning how to reuse them effectively several times.

2.2.3 Concept of Reuse

Packaging was developed to keep safe the products until the time they are used or consumed. This means that most of the packages are still in perfect condition when empty (eg. glass jars, plastic containers). Depending on their condition they could continue to be used for the same purpose as designed (Pongrácz, 2007).

Reuse can be seen as a more environmentally friendly solution than recycling, as it aims to use a product again for its original purpose (conventional reuse) or to fulfil a different function (creative reuse) without reprocessing. In fact, reuse is one of the oldest forms of solid waste management, long before recycling was technically possible (NYC, 2017).

The European Union (European Commission, 2008) defines reuse as any operation by which products or components that are not waste are used again for the same purpose for which they were initially produced.

In contrast to recycling, that diverts materials in the waste stream from landfills or incinerators, reuse helps to save money, energy and resources as it extends the useful life of products and keeps the items out of the waste stream by redistributing and circulating them locally.

According to the report "Waste prevention in Europe: policies, status and trends in reuse in 2017" (Wilts, Bahn-Walkowiak and Hoogeveen, 2018) published by the European Environment Agency, reuse is specifically addressed in most of the waste prevention plans of the EU countries. Some of these countries went even deeper and defined general goals for reuse implemented quantitative targets for reuse and/or introduced reuse indicators.

Portugal has a waste prevention program that was implemented in 2016 and lasts until 2020. This program contains general objectives for reuse but does not include quantitative targets or indicators, what makes difficult evaluate the progress done. Even though Portugal has not established concrete goals, the country is engaged in reuse as it is included in more governmental general recommendations.

Although reuse has so many benefits, some authors mentioned two main disadvantages that should be taken into consideration: the time for sorting and preparing an item to be reused and the cleaning the usually reusable products need.

2.2.4 Environmental Impact of Packaging Materials

Nowadays production and consumption happen at different places and times and this fact is highlighted as the key cause for the increase in the demand for packaging.

More and more people are moving to urbanized societies and the prediction is that by 2025, two-thirds of the world's population will live in cities (Pongrácz, 2007). This level of urbanization requires a huge distribution of goods, mainly foods, and packaging is required for allowing it.

Besides the relocation of people from rural to urbanized areas, the world's population has also been increasing. In the last 50 years, the world's population has more than doubled, taking with it a massive increase in the demand for products and services. The global economy has grown from just 1,35 trillion dollars in 1960 to 60 trillion dollars in 2011, putting a great pressure into our environment, with great impacts from increased CO2 emissions to the reduction of natural resources.

As a result of this phenomenon, packaging has been seen as a major problem for the environment, mainly for the depletion of natural resources and the effects of wastes and emissions. Actually, it also has positive impacts, as it allows the easy distribution of goods from producers to consumers, but the negative ones are a huge problem for modern society being considered a priority environmental problem in the world.

On table 2, it is possible to see that the availability of packaging materials is under pressure as some materials have limited resources. The renewable resources have been growing for almost all materials, but the consumption rate is increasing faster than the renewable resources, having a huge dependency on fossil resources.

The manufacturing of packaging has also great impacts on the surrounding ecosystems. Water and air pollution are pointed out as the main impacts.

One of the most water-polluting activities is paper production as it realises biological oxygen demand, chemical oxygen demand, volatile suspended solids and total suspended solids (Pongrácz, 2007). Hydrocarbon pollution can also arise from adhesive, coatings and inks used in packages. Remaining products on the packaging can also create landfill leachates.

The air pollution is also a reality, mainly caused by landfill sites, as a consequence of the decomposition of wood and paper, releasing CO_2 and methane, but also by glass and steel manufacturing.

Table 2 - Availability of packaging raw materials. Source: Pongrácz, 2007 (adapted).

Packaging Material	Raw Material	Fossil Resource	Renewable Resource	Overall Resource
Paper/board	Wood, natural fibres	Nil	All	Very abundant
	Auxiliary chemicals	All	Nil	
Iron	Iron ore	About half	About half (recycling)	Limited
	Scrap iron			
Aluminium	Aluminium ore	The majority (but plentiful)	Minority (recycling, but growing)	Moderately limited
	Scrap			
Glass	Sand	The majority (but abundant)	Minority (recycling, but growing)	Abundant
	Soda			
Plastics	Crude oil	Almost all	Little	Moderately limited
	Biomass	Nil	All	Very abundant
	Auxiliary materials	Some, but abundant	Some	Very small factor, no limitation

Besides the impacts on the raw materials resources and the environmental impacts of manufacturing, the packaging is also being a problem in logistics and transports, mainly because of the size, shape and weight of it, not allowing optimize the transport and handling.

If to some products the packaging weight is not representative such us a pasta PE bag, to others it represents more than 50% of the finish good total weight. In truth, as can be seen in table 3, for products such as a box of 25 tea bags, the packaging weight represents 160% of the products weight. This means that companies are wasting more loading capacity to transport the packaging than for the product itself.

This behaviour is heading to the need for more vehicles to transport the products and consequently to more transport-related emissions of CO_2, SO_2, NO_x, dust and hydrocarbons.

Because of the huge amount of packaging that is taken home by consumers, packaging waste represents a challenge for the management of waste in cities. Packaging waste is an unpleasant sight, constitutes a danger for animals and may be a health hazard to humans (Pearce and Turner, 1992).

According to the European Environment Agency, the waste generated by packaging in Portugal has raised more than 50% between 1998 and 2008 (figure 19), and the population has only raised 3.7% in the same period, from 10,186,634 to 10,563,014. This means that the amount for packaging waste generated for each Portuguese has been raising along the years.

Table 3 - Percentage of package's weight compared to the packed product. Source: Pongrácz, 2007 (adapted).

1-10%	
1	500 g of pasta in PE bag
3	1 l soft drink in PET bottle
5,3	2 dl yoghurt in a plastic cup
7,4	10 eggs in pulp tray
9,5	Fabric softener in HDPE bottle
11-20%	
11,9	85 g cat food in an aluminium pouch
13,4	500 g of canned food
18,5	2 dl of shampoo in a plastic bottle
21-30%	
23	400 g of cereal in PP bag and paper box
25	150 g of canned food
31-40%	
34	Deo-roll in HPDE bottle
40	150 g of cereal in PP bag and paper box
49	1 l dishwasher liquid
41-60%	
53	0,3 l glass bottle of beer
56	Deodorant in a spray bottle
57	150 g jam in glass jar
61-100%	
68	0,5 l salad dressing in a glass bottle
80	0,5 l oil in a glass bottle
>100%	
160	A box of 25 tea bags
611	20 g of seasoning in a glass bottle

On 2009 and 2010 there was a small decrease but it is related to the economic crisis lived in Portugal by that time. Unfortunately, it is not related to the improvement of the consumption patterns.

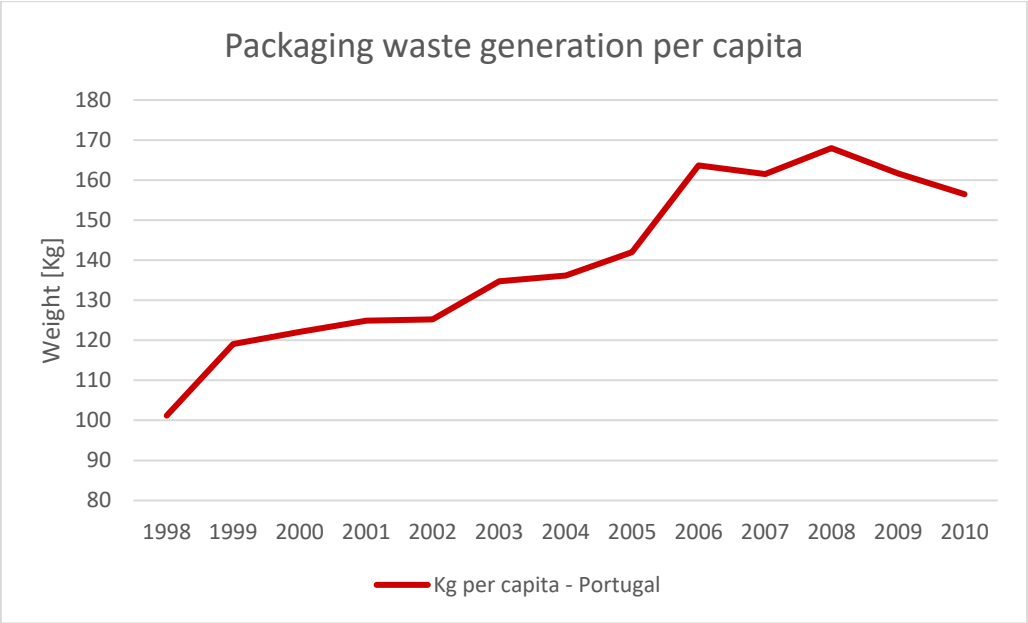

Figure 19 - Packaging waste generation per capita in Portugal. Source: EEA (2015).

However, the society of today in getting more and more conscious about these impacts, many customers are starting to select products taking into consideration the sustainability of the packaging, but until now it is not possible to see this represented on the data available.

2.2.5 Environmental Associations in Portugal

Portugal has always been a country with environmental concerns. Therefore, there are some important, governmental and non-governmental, environmental entities that lead the nature conservation, the defence of the environment and that work together to achieve the environmental goals established by international organizations, such as European Union and United Nations.

The most representative institutions and associations in the country are presented below, but there are more than 100 environmental groups that lead mainly local activities and that are still crucial for the sustainable development in Portugal.

Agência Portuguesa do Ambiente

The Portuguese environmental ministry created in 2012 the Portuguese Environmental Agency *(Agência Portuguesa do Ambiente*), as a result of the fusion between nine governmental institutions that had as a mission the environment protection.

Figure 20 - Portuguese Environmental Agency institutional image.

This agency (figure 20) is responsible for the monitoring, planning and evaluation, licensing and control, being the main environmental regulator in Portugal. In fact, it works in different areas such as water, waste, environmental impacts evaluation, circular economy, among others, and it is the agency that is responsible for the Status Report of the Environment in Portugal.

The Portuguese Environmental Agency has settled as a mission to propose, develop and monitor the integrated management of the environmental policies and of sustainable development, working closely with public and private institutions that have the same goal.

Quercus

Quercus (figure 21) is a national non-governmental environmental organization founded in 1985 and it is constituted by citizens that are interested in the nature conservation and in the environmental defence in general.

Figure 21 - Quercus institutional image.

It is divided into 18 regional affiliates that aim to have local intervention in the environment protection.

The association's scope covers diverse areas of environmental concern such as energy, water, waste, climate changes, forest and sustainable consumption, mainly supported by the permanent project groups.

Liga para a proteção da Natureza

The Alliance for Nature Protection (*Liga para a proteção da Natureza*) was founded in 1948 and is the oldest environmental association in the Iberian Peninsula.

This organization (figure 22) develops activities to achieve its main goals – environmental defence and conservation of natural patrimony, species and ecosystem diversity.

Figure 22 - Alliance for Nature Protection institutional image.

It has also settled some specific goals, where can be highlighted the contribution for the environmental information dissemination and promoting the environmental citizenship encouraging the public participation through environmental education workshops.

2.3 Survey and Data Processing

To have a clear picture of the Portuguese packaging industry, a survey was done to several packaging companies.

The questionnaire used during this survey was strategically formulated in order to get the best results, congruent and reliable answers that would lead the study to factual conclusions.

2.3.1 Techniques Used in the Questionnaire Formulation

The formulation of this questionnaire used some techniques in order to make it understandable and easy to fill by the people surveyed, but also that some cross-check questions were made in order to understand how congruent answers were.

It was constituted by 30 questions focused on eco-design, environmental management, sustainable development, among others that were important for the study.

To better collect data that was easy to work with, the following types of questions were used:

- Multiple choice questions;
- Dichotomous questions;
- Scaling questions;
- Open questions – for justifying previous answers.

The questionnaire was organized into five groups of questions to better unify the information, and with specific investigation hypothesis, making it easy to be answered but also to be analysed.

Each of these groups has objective questions in order to obtain important information and variables that will be crucial for the statistical analysis that is going to be made afterwards in the study.

Some questions were made to confirm previous answers, this means that contradictions on the answers were easily detectable, if needed. For instance, in the group number IV after the dichotomous question "Is the environmental impact of waste monitored somehow?" there is an open question to understand how the environmental impact was really monitored: "If yes, how?".

After having the questionnaire ready, it was distributed through the Portuguese packaging companies using the platform of Google Forms®, which allowed to gather all the answers in an easy and effective way.

2.3.2 Techniques Used in the Questionnaire Formulation

The formulation of the questionnaire took into consideration the expertise achieved by some authors and researchers in their previous studies. Therefore, good practices in questionnaire formulation, type of questions, language used, size and organization of the questionnaire were used to develop the survey needed for this study in a way that could be possible to achieve results that allow to get reliable conclusions and infer about the packaging Industry.

As the objective of the survey is to test and quantify hypotheses and analyse statically the data, a formal standardised questionnaire was designed. According to Crawford (1997), a survey will be successful if:

- The questionnaire meets the research objectives;
- The questionnaire is organized and worked to encourage respondents to provide accurate, unbiased and complete information;
- The questions are easy to understand and easy to record;
- The interview is brief and to the point in order to keep the respondent interested.

Being so important for the survey success, all the 4 points were included in the questionnaire design, having clear and brief questions that were organized in a way that respondents would give answers that meet the research objectives, as well as the experience of researchers that lead studies that used surveys as a research tool to obtain detailed data.

Moreno (2017) achieved great results and conclusions in a study about the environmental commitment of Portuguese painting industries using dichotomous questions, open short answer questions and multiple-choice questions such as “Which of the enamels is more expensive? a) Organic Solvent-based; b) Water based”. In fact, the data collected allowed Moreno (2017) to infer about all the Portuguese paint industry even though only part of the companies answered the survey.

A survey was also critical for Lee, Lee, Choi and Lee (2016) having achieved good quantitative data that allowed to reach reliable conclusions.

Mostly multiple-choice questions like “For what kind of market do you manufacture mostly? a) National; b) Mixed; c) Foreign.” were used by Silva (2017) to study the usage of ecological products by the printing industry, having achieved the objectives of the study and great conclusions.

Therefore, the same type of questions was used in this questionnaire in a way that was also possible to achieve good conclusions and deductions about the packaging industry in Portugal, such as the question “To which market sector is the company more oriented? a) Food; b) Pharmacy; c) Automotive industry; d) Chemical products; e) Consumer goods; f) Other. Which?”

2.3.3 Sample Size and Confidence Level

According to the Portuguese National Statistics Institute (INE), in 2016 there were 641 packaging manufactures In Portugal.

With the help of APIGRAF and some research, 50 companies (8%) were involved in the study.

A confidence level of 95% was considered for the statistical analysis of the data collected.

2.3.4 Statistical Treatment of Results

As previously mentioned, the survey was created and distributed via email with the usage of Google Forms®. It was also requested by phone calls and with the support of industrial associations the availability of companies to answer the questionnaire as it was important for the study. The survey was conducted between March 2018 and July 2018.

After having all data collected and organized in MS Excel® it was uploaded to the statistical software R®.

With R® it was possible to build, analyse, test and prepare tables and graphs that illustrate the results in a clear way.

2.3.5 Conclusions Drawing

In the analysis of the data collected several statistical techniques were used to achieve reliable conclusions.

An Index of Eco-Design Implementation was developed with the most valuable answers and several hypotheses were tested with it in order to understand how variables could be statistically related between them and finally allow the conclusions drawing about packaging industry in Portugal.

DEVELOPMENT

3 DEVELOPMENT

3.1 Specific Goals of the Practical Work

As previously mentioned, this study has as the main goal to evaluate the implementation of Eco-design in the Portuguese packaging industry.

To achieve this goal several specific goals needed to be set in order to guide the development of the study and to guarantee the conclusions drawing:

- Identify packaging manufacturers in Portugal and the main areas where they are based in;
- Describe the size of packaging companies in a number of employees, turnover and the percentage of exports, so that it was possible to understand if there is any correlation between this data and the environmental awareness;
- Verify if there is any kind of counselling or guidance given to customers to take more ecological packages;
- Verify if the age and academic success of supply chain responsible influences the eco-design development in the companies;
- Analyse if the environmental mind-set and awareness of the administration and employees influence the introduction of eco-design in the packaging development process;
- Understand if the development of eco-design in companies is related to the company environmental innovation predisposition.

These objectives aimed to understand how eco-design is seen by the packaging industry in Portugal, if there are any signs of ecological awareness in the industry and if the sustainable thinking is seen as a key figure for the success of the companies.

3.2 Entities Contacted

For the success of the study, some entities were contacted to obtain crucial information.

Several industrial associations were contacted to obtain some data about the packaging industry in Portugal, but only APIGRAF replied with success. Unfortunately, after several emails sent and a few phone calls, the other industrial associations never showed availability to share information about the industries that they represent.

The validation of the questionnaire used as a tool for this study was done for packaging specialist of two companies, *Calheiros Embalagens S.A.* and *Bosch Car Multimédia Portugal S.A.*, and one industry association, APIGRAF.

All packaging manufactures in Portugal identified by EPIGRAF, and others identified by research were also contacted to answer to the questionnaire.

3.3 Questionnaire Structure: Underlying Principles

As stated before, the questionnaire was organized into five groups of questions, each one has questions about a certain topic of interest to the study.

Each of these groups has identified questions and objective variables, as can be seen in table 4.

Table 4 - Group of questions and variables

Groups	Questions	Variables
I - Interviewed Characterization	1, 2, 3	Interviewed age, Education degree, Job position.
II - Company Characterization	4, 5, 6, 7, 8, 9, 10, 11, 12, 13	Company age, Location, Packaging type and market, Number of employees, Business volume, Innovation development, Industrial association partnership.
III - Supply Chain Dept. Characterization	14, 15, 16	Supply Chain Responsible Age, Education degree, Purchase decision factors.
IV - Environmental Characterization	17, 18, 19, 20, 21, 22, 23, 24, 25, 26	Environmental training frequency, Environmental certification, Customer environmental guidance, Packaging waste impact monitoring, Sustainability KPIs.
V - Product Innovation Characterization	27, 28, 29, 30	Innovation mindset, Environmental packaging development, Eco-design importance.

The group 1 aims to get information about the interviewed person, such as age, education and job position, while group 2 focus on the company characterization, collecting data as company age, location and packaging types.

The supply chain department is characterized in the group 3, and the group 4 aims to get information about the environmental characterization of the company, having as variables such the environmental training frequency and packaging waste impact monitoring.

The final group, number 5, has as goal to get information about the company predisposition for the eco-design, sustainable development and innovation.

All these groups were fundamental to achieve the specific objectives of this study.

3.4 Questionnaire Validation and Final Adjustments

To assure that the questionnaire was easily understandable, and it was facing the established goals of the study it was validated for some packaging specialists.

Two packaging professionals from two of the most important players in the industry were contacted to check and validate the questionnaire.

A packaging developer, Mr Paulo Sousa, from *Bosch Car Multimédia Portugal S.A.*, one of the most important automotive parts producers in the country, validated the questionnaire after careful analysis (appendices 6.2.1).

Mr Marcelo Azevedo, production responsible in *Calheiros Embalagens S.A.*, a major paper packaging producer in Portugal, mentioned that the questions of the survey were adequate to achieve the goal of the study, and therefore it was validated (appendices 6.2.2).

The questionnaire was also approved by Mr Jorge Lopes (appendices 6.2.3), a representative of APIGRAF, highlighting that the questionnaire should be distributed in a way that allowed the quick response of interviewers.

This point was taken into consideration in the survey as the questionnaires were distributed through Google Forms®, an intuitive and user-friendly tool that collected the survey data in an effective e quick way.

3.5 Consulted Sample and Effective Sample

With the support of APIGRAF and with some research, 50 companies were contacted in order to take part in this study, making the consulted sample.

From the 50 companies, only 33 manufacturers (66%) constituted the effective sample, having an active role in the dissertation, as they answered successfully the questionnaire distributed.

3.6 Results Summary

For the accomplishment of this study, a lot of information about companies and their employees were necessary. As already mentioned this useful information was collected via a survey that was organized into five groups (appendices 6.1).

In the 1st group, the questions allowed to characterize the survey respondents. As can be seen in figure 23, the packaging industry has quite young professionals as 54% of respondents are 40 years old or less, while there are 3% that is more than 60 years old.

It was also possible to figure that the majority of respondents had university education with graduation (46%) or master (12%) degrees. On the other hand, there are 18% respondents that have only completed the 2nd (12%) or the 3rd (6%) stages of basic education, existing 24% that finished the high school.

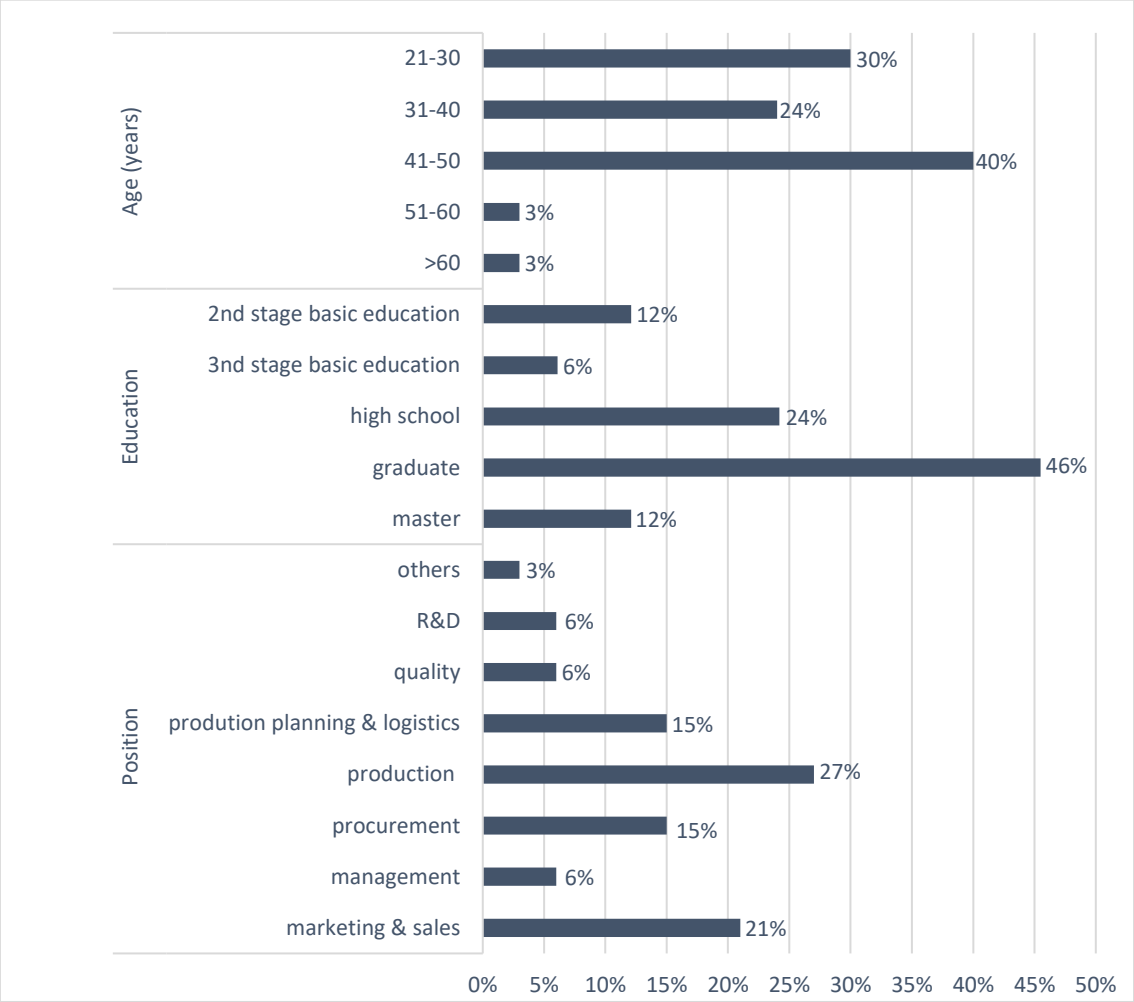

Figure 23 – Respondents' Characterization.

Regarding the job position in the company, production (27%) and marketing & sales (21%) are the departments were almost half of the respondents work. With 15% of

respondents, there are two departments, production planning & logistics and procurement, making the third and fourth most represented departments.

After having a clear view of the interviewed packaging professionals, it was essential to characterize the companies of the study with the questions of the 2nd group.

In figure 24, it can be figured that when it comes to turn over most of the companies are small sized (40%) but when the company's size is evaluated according to the number of employees, the majority are medium companies (64%).

Paper and corrugated (49%) is by far the most common packaging material in Portugal being used mainly for food packaging, as 63% of the companies referred that were oriented for food market sector. It was also noticed that R&D departments are present in 88% of the companies.

The packaging companies surveyed are mainly localized in Aveiro (34%) and Porto (18%) districts and most of them were founded in the 1950s (24%) and 1960s (28%). 94% of them are exporters and, from these companies, 55% have an exportation volume that represents less than 25% of the total business volume and there 42% were exportation represents between 25% and 50% of the total business volume. Only for one company, exportations represent more than 75% of the total business volume.

From all these companies, only 52% are included in industry associations.

The questionnaire also focused on the purchasing department on the 3rd group of questions, characterizing the department through the supply chain manager (figure 25) and the deciding factors for the purchasing of products.

The packaging industry, according to the collected data, seems to give young professionals an opportunity to manage the supply chain department, as 94% of the companies have to supply chain managers with 50 years old or less. In fact, 36% of the managers are between 31 and 40 years old.

Surprisingly, 12 managers (36%) out of the 33 companies have only completed high school, while 48% and 12% have completed graduation and master's degree, respectively.

Regarding the decision aspects that are taken into consideration for the purchasing of products and/or raw materials, the majority of respondents said that the purchasing department considered that all the aspects were very important or extremely important.

In figure 26, can be observed that there are two aspects that have 100% of respondents saying that they are very important or extremely important - quality and cost. In truth, the cost was considered the most important factor, with 87% of the interviewed saying that is extremely important.

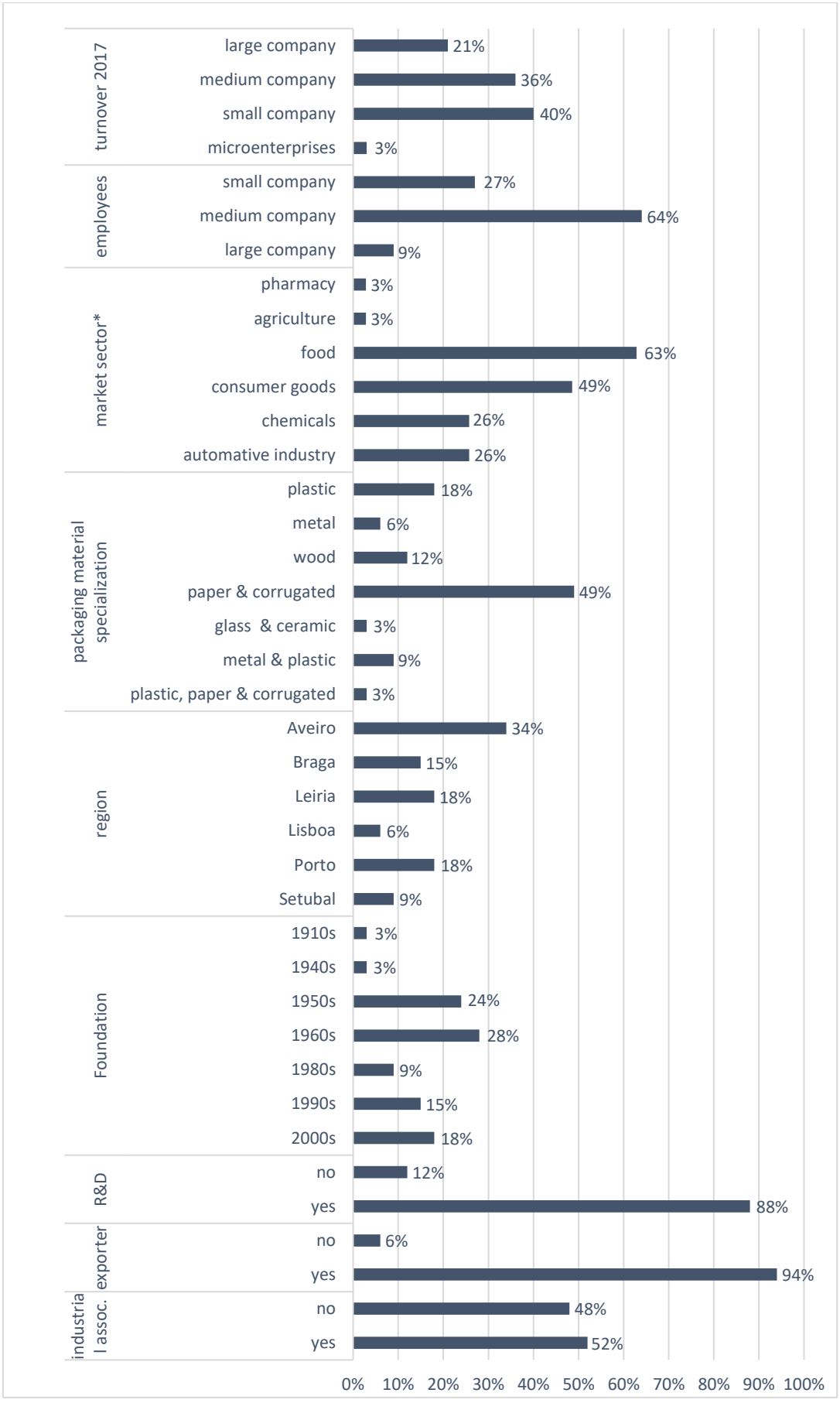

Figure 24 - Companies' Characterization

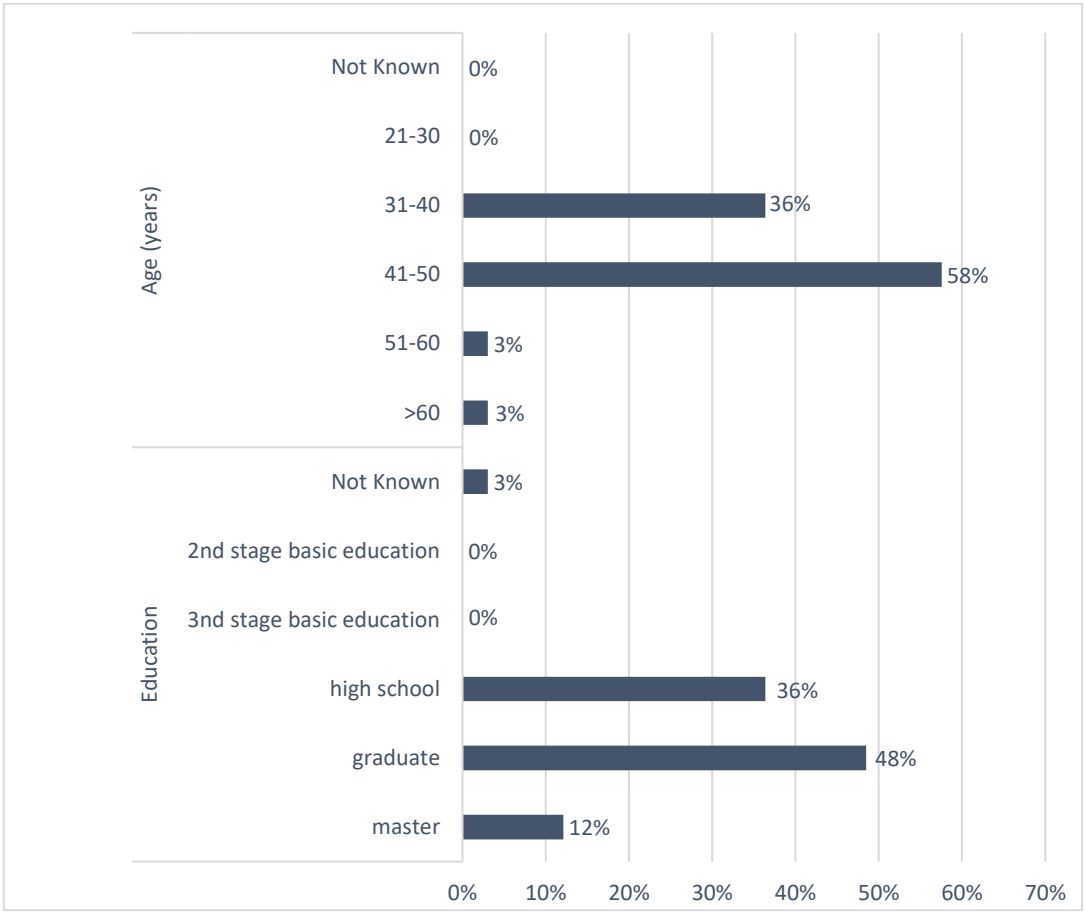

Figure 25 - Supply Chain Manager Characterization.

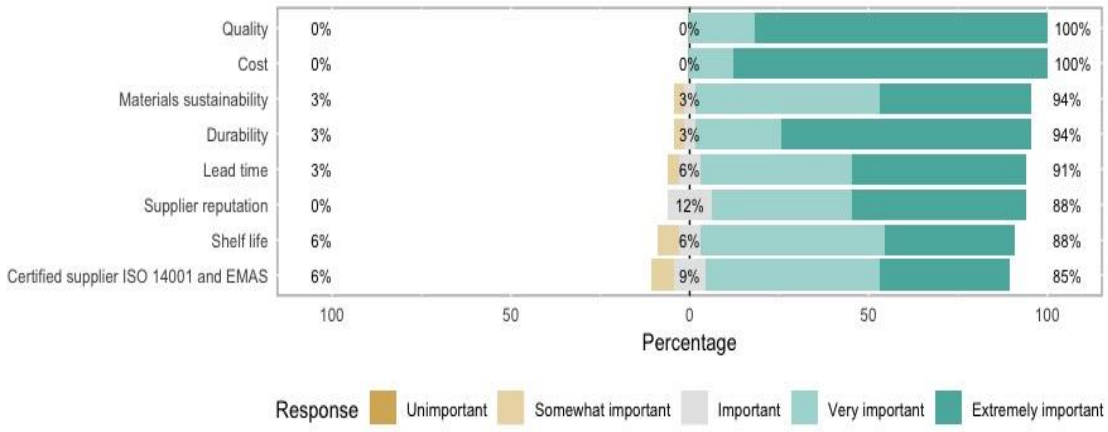

Figure 26 - Decision factors' importance for the purchasing of products and/or raw materials.

It can be highlighted that materials sustainability is the 3rd most important aspect, as 94% considered that it is very or extremely important.

On the other hand, it is possible to observe that a supplier certified with ISO 14001 and registered in EMAS is not so important when buying products or raw materials, as 15% considered that this aspect was only important or somewhat important.

In the 4th group of questions, the survey meant to characterize environmentally the companies, starting to check if the respondents believed that their company had a culture focused on Eco-design.

In figure 26, it is possible to check that 73% of respondents believe that there is an eco-design culture in their companies.

To understand how deeper this culture was implemented in the companies, it was checked if systematic training on environmental responsibility, sustainability and eco-design was performed regularly.

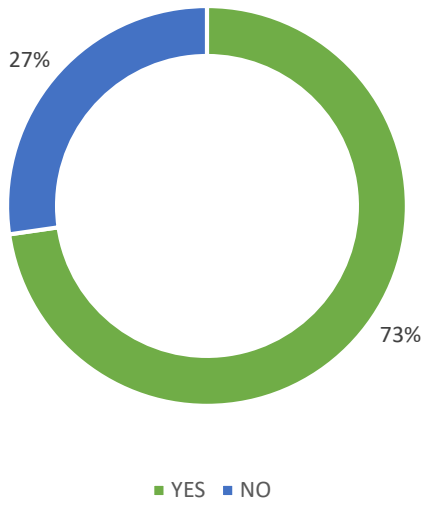

Figure 27 - Eco-design culture in companies.

This kind of training is taken in 85% of the companies surveyed. As can be seen on figure 28, 52% of the people interviewed have training in environmental responsibility, sustainability and Eco-Design one time every year, while 18% has it one time every two years and 15% is used to have this training one time every six months.

The importance given to some aspects in terms of environmental impact was also evaluated. From the five aspects of concern presented, two were considered the most important, energy consumption and packaging weight, with 97% of the people saying that these factors were very or extremely important.

The paint used and the easiness of storying and transport the packaging, were considered the least important aspects. As stated in figure 29, 3% of the respondents mentioned that the paint of the packaging was unimportant and 27% of the people claiming that the storage and transport were only important or somewhat important.

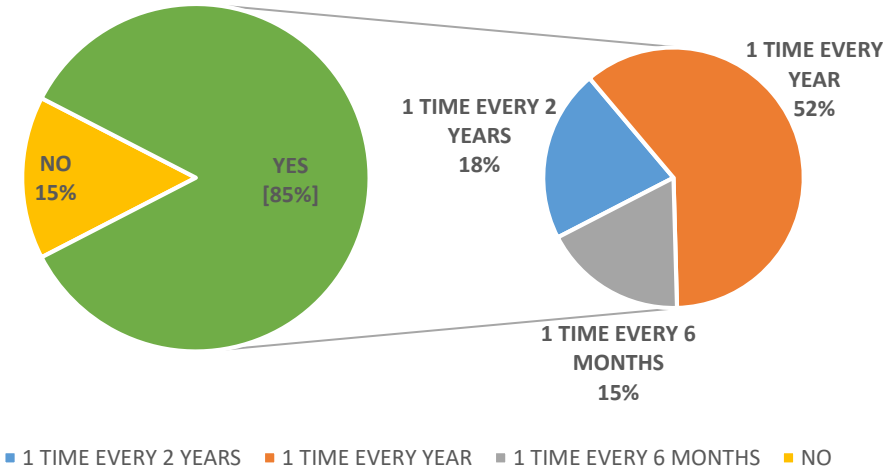

Figure 28 - Training existence and frequency.

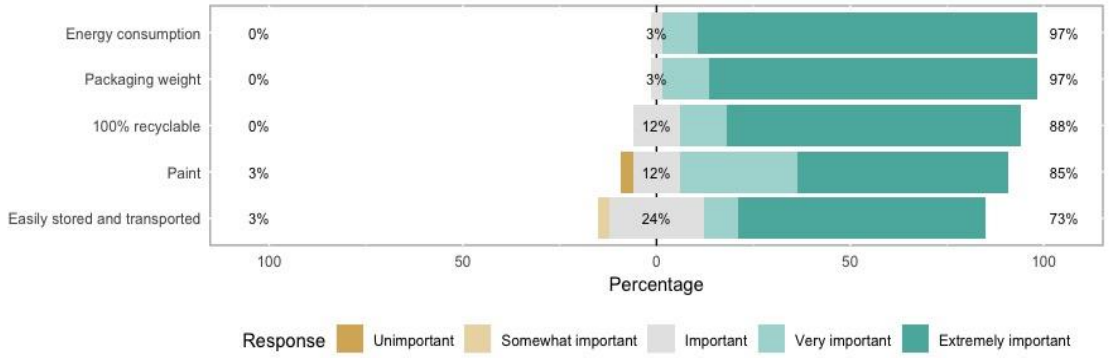

Figure 29 - Environmental impact aspects of concern.

The total recyclability of the package was seen by interviewed the 3rd most important factor, with 88% saying that it is a very or extremely important factor of concern when it comes to environmental impacts.

To further improve the environmental characterization of the companies, some dichotomous questions were made in order to get reliable answers.

In figure 30, it is possible to check that only 52% of the companies are certified in ISO 14001. When it comes to the implementation of the Eco-Management and Audit Scheme (EMAS) the results are even worst as 76% of the companies do not present it, having a huge margin of progress in this area.

94% of the companies admit that there is a customer guidance to opt for more ecological packaging solutions what concurs to the importance given to this aspect by respondents, as 97% of them referred that this aspect is very or extremely important.

When it comes to packaging waste, 55% of the companies do not have any tool or KPI that allows monitoring this indicator, what shows that manufacturers do not know the effective environmental impacts of the packaging produced by them.

In accordance with what was stated before, most of the companies (70%) do not have any control over the evolution of the sustainability of their products over time.

In contrast to these results, 85% of the respondents believe that the socioeconomic success of the company relies directly on the internal environmental policies and the application of them on the process and/or products.

These results show that regardless of the underdevelopment of companies in terms of environmental control, there's an environmental awareness implemented in packaging professionals.

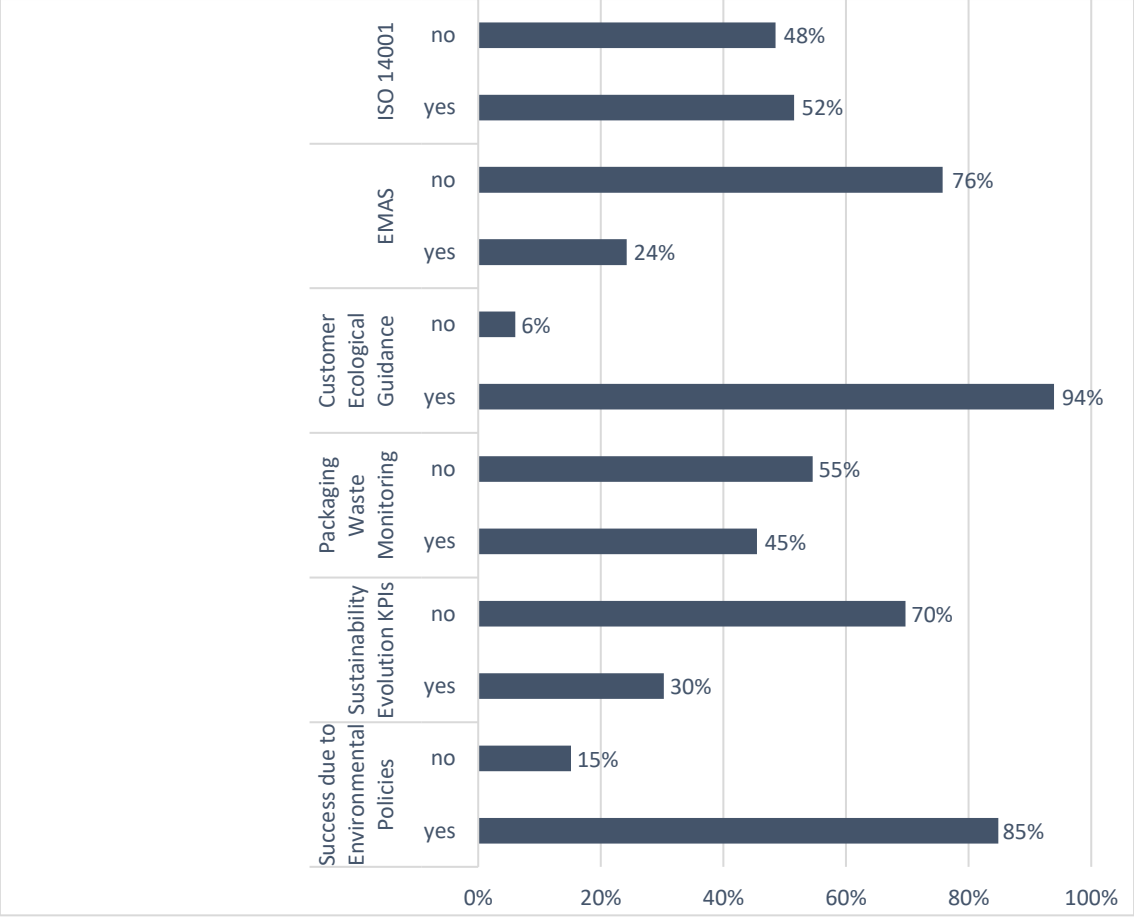

Figure 30 - Environmental characterization of companies.

Finally, some question intended to illustrate the product development process in the companies, making the 5th group of questions.

Almost 70% of the companies considered themselves as extremely innovative companies. Therefore, it was important to classify some aspects of interest regarding eco-design and innovation, and product development.

Respondents referred that process improvement (100%) and eco-innovation in the packaging industry (97%) were very or extremely important aspects to have into consideration.

On the other hand, government incentives and research partnerships are not so much seen as crucial for ecological success in product development. 6% of interviewed consider that government incentives to eco-design are unimportant or somewhat important, and 15% consider that university and research partnerships are only important, not giving too much attention to these aspects when it comes to product development (figure 31).

Government incentives appear in the middle of the table, but it seems to have some discordance between respondents as 3% of them believe that is aspect is only somewhat important.

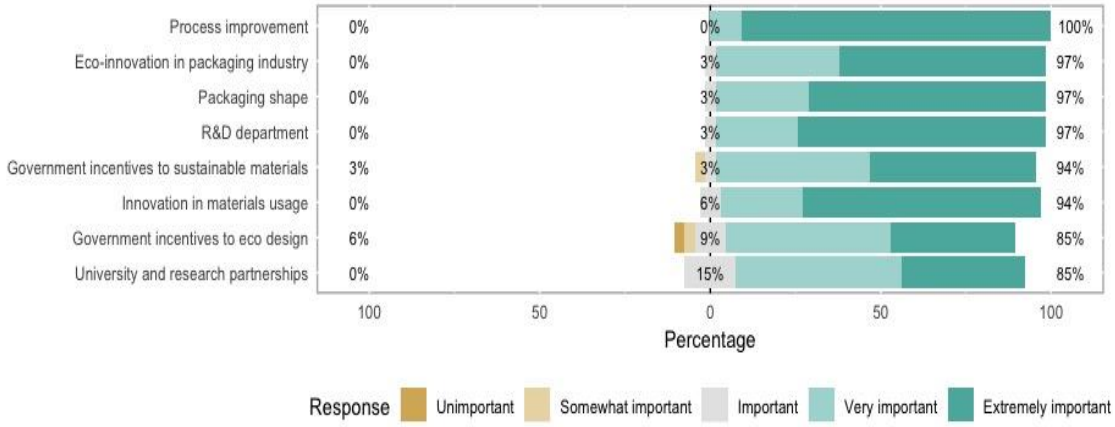

Figure 31 - Aspects of concern for ecological product development.

Regardless of what was mentioned above, it seems to have a general opinion of respondents, considering all aspects with great importance for ecological product innovation.

When interviewed were asked about the environmental impacts of the products, 76 % answered that their company seeks constantly to improve the environmental impacts of packaging.

As the final question of the survey, respondents were asked to classify the importance of Eco-design. In figure 32 it can be observed that 58% of respondents believe that Eco-design is extremely important for the packaging industry and 24% think that it is very important.

Only 3% of the interviewed stated that Eco-design was unimportant what shows that packaging professionals are committed with ecological concerns, what will possibly allow packaging manufacturers to improve their future performance in this area.

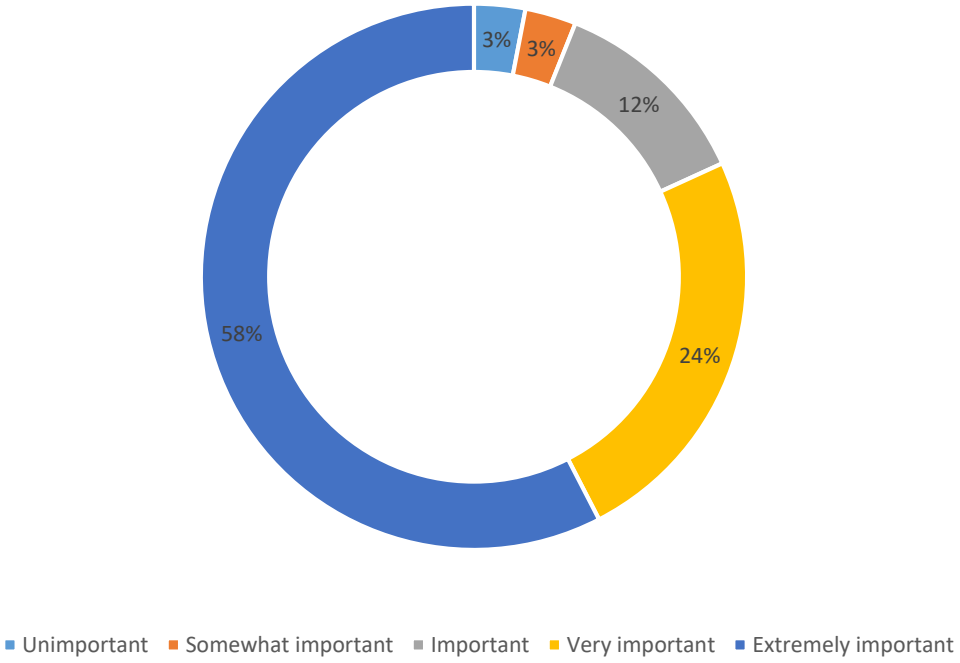

Figure 32 - Importance of Eco-design.

3.7 Results Statistical Treatment

Having analysed all the results, it is crucial to define investigation hypothesis that would face the main and the specific goals of this study. In table 5 it is possible to see the investigation hypothesis that was established for this study as well as the variables and their respective questions and groups that were statistically tested.

As a way to measure how much companies were committed with eco-design and sustainable practices, it was created the Eco-Design Development Index. Several questions of the survey were used to build this index, attributing a specific score according to the answer given (table 6).

The questions were selected according to its nature. Only factual and company related questions were selected, not including variables that depend on respondent's opinion, as they would influence the index classification and not illustrate the reality of the industry.

Having established the score of the considered answers, the index was calculated for all the companies involved in the study, having achieved a classification that is presented on a histogram.

Table 5 - Investigation Hypothesis and affected variables, questions and groups.

Investigation Hypothesis	Variables	Questions	Groups
H1: The age, the education degree and professional success of employees influence the eco-design implementation in the company.	Interviewed age, Education degree, Job position.	1, 2, 3	**I - Interviewed Characterization**
H2: The company characteristics influence the eco-design implementation in the company.	Company age, Location, Number of employees, Business volume, Innovation development, Industrial association partnership.	4, 5, 6, 7, 8, 9, 10, 11, 12, 13	**II - Company Characterization**
H3: The age, the education degree and the decision factors of supply chain responsible influence the eco-design implementation in the company.	Supply Chain Responsible Age, Education degree, Purchase decision factors.	14, 15, 16	**III - Supply Chain Dept. Characterization**
H4: The Environmental mindset and awareness of the administration and employees influence the eco-design implementation in the company.	Environmental training frequency, Customer environmental guidance.	19, 22, 26	**IV - Environmental Characterization**
H5: The company environmental innovation predisposition influences the eco-design implementation in the company.	Environmental packaging development, Eco-design importance.	28, 29, 30	**V - Product Innovation Characterization**

In the histogram of figure 33 can be seen the distribution of the Eco-design development index. It is possible to see that the minimum value of Eco-design development is 0, revealing that these companies do not have any interest in sustainability, environment and ecological product design.

On the other hand, there is a company that achieved the maximum score on the index, 9, showing a complete awareness and environmental thinking spread through all processes, being committed with eco-design.

The mean of the Eco-design index is 5.6 with a standard deviation 2.18. The median is 6 and the most frequent score is 7.

Having classified the companies into the Eco-design development index, it becomes important to test the investigation hypotheses and understand how they could be statistically related to the index classification of the company.

In order to easily test the hypothesis and due to the lack of respondents, variable grouping was done as can be seen on table 7.

Table 6 - Eco-design implementation index - questions and scores.

Question	Question Detail	Answer	Score
17	ECO-DESIGN CULTURE IN COMPANY	Yes	1
		No	0
18	TRAINING IN ENVIRONMENTAL RESPONSIBILITY, SUSTAINABILITY AND ECO-DESIGN	Yes	1
		No	0
20	CERTIFIED COMPANY - ISO 14001	Yes	1
		No	0
21	CERTIFIED COMPANY - EMAS	Yes	1
		No	0
23	COMMERCIAL DEPARTMENT GUIDANCE FOR ECOLOGICAL PACKAGING	Yes	1
		No	0
24	ENVIRONMENTAL IMPACT MONITORING OF PACKAGING WASTE	Yes	1
		No	0
25	PACKAGING SUSTAINABILITY KPIs	Yes	1
		No	0
27	COMPANY WILLINGNESS FOR PRODUCT INNOVATION	1	-2
		2	-1
		3	0
		4	1
		5	2

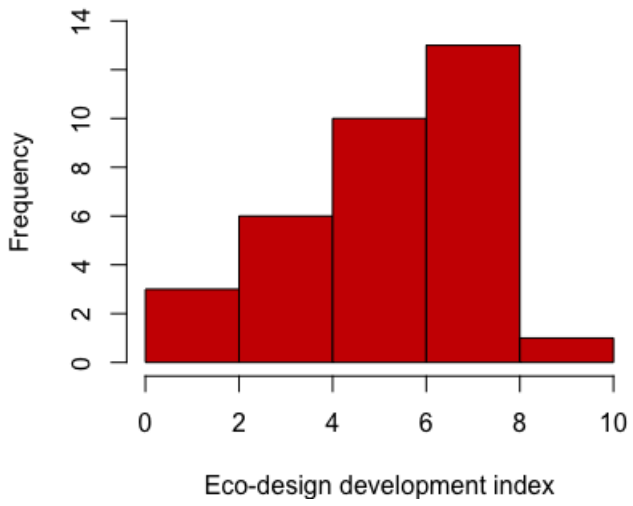

Figure 33 - Histogram of Eco-design development index.

Table 7 - Variable grouping for statistical analysis.

Variable	Grouping	Description
Age	<40 years old	Young Professional
	>= 40	Mature Professional
Education Level	Basic Education;	1st, 2nd and 3rd Cycle of Basic Education;
	High School Education;	Secondary Education;
	University Education.	Higher Education - graduation, master, PhD.
Job Position	Direct;	Production, Planning & Logistics, Quality;
	Indirect.	Management, Supply Chain & Procurement, Marketing & Sales, Research & Development.
Company Age	<10 years;	New company;
	>=10 and <30;	Mature company;
	>=30.	Experienced company.
Location	North;	Viana do Castelo, Braga, Vila Real, Bragança, Porto, Viseu, Aveiro, Guarda;
	Centre;	Coimbra, Leiria, Castelo Branco, Santarém, Portalegre, Lisboa;
	South.	Setúbal, Beja, Évora, Faro;
Number of Employees	<50 employees;	Small Company (includes Micro-enterprises);
	>= 50 and <250 employees;	Medium Company;
	>= 250 employees.	Large Company.
Turnover	<= 10 million euros;	Small Company (includes Micro-enterprises);
	> 10 and <= 50 million euros;	Medium Company;
	> 50 million euros.	Large Company.
Job position	Direct	Production, Planning & Logistics, Quality;
	Indirect	Management, Supply chain & Procurement, Marketing & Sales, Research & Development

Several statistical techniques and methods were used to test the investigation hypothesis, as can be seen in table 8. Due to the dimension of the sample, a nonparametric statistical approach was carried on the study.

Table 8 - Investigation hypothesis and statistical methodology.

Investigation Hypothesis	Method
H_1: The age, the education degree and professional success of employees influence the eco-design implementation in the company.	Kruskall-Wallis test Mann-Whitney test
H_2: The company characteristics influence the eco-design implementation in the company.	Kruskall-Wallis test Mann-Whitney test
H_3: The age, the education degree and the decision factors of supply chain responsible influence the eco-design implementation in the company.	Kruskall-Wallis test Spearman Coefficient
H_4: The Environmental mindset and awareness of the administration and employees influence the eco-design implementation in the company.	Mann-Whitney test Spearman Coefficient
H_5: The company environmental innovation predisposition influences the eco-design implementation in the company.	Mann-Whitney test Spearman Coefficient

Investigation Hypothesis H_1

The first hypothesis tries to understand how the interviewed characteristics' as an employee of a packaging manufacture company may influence effectively the eco-design implementation on the company:

H_0: The age, the education degree and professional success of employees do not influence the eco-design implementation in the company.

Vs

H_A: The age, the education degree and professional success of employees influences the eco-design implementation in the company.

Kruskal-Wallis and Mann-Whitney tests were conducted to verify the existence of the influence of the age, education degree and professional success of interviewed employees in the eco-design implementation in the packaging company. Table 9 shows the results of the tests and on the figure 34, eco-design implementation index is summarized.

Among the two categories of respondent's ages (Mature professionals, n=16; Young professionals, n=17) no significant differences were found (W=100.500; p=0.202). Despite the observed differences between interviewed who have direct job positions

(n=16) and the ones who have indirect job positions (n=17) it was not possible to conclude that these differences are statistically significant (W=151.000; p=0.597).

Table 9 - Test results for H_1.

Variables	Test hypotheses	Test statistic	p
Interviewed age	$H_0: F_{<40years} = F_{40\geq years}$ $H_A: F_{<40years} \neq F_{40\geq years}$	W=100.500	0.202
Education degree	$H_0: F_{Basic} = F_{High} = F_{Graduate}$ H_A: At least one of the populations tends to yield larger observations than at least one of the other populations	$\chi^2_{(2)}$=1.114	0.573
Job position	$H_0: F_{Direct} = F_{Indirect}$ $H_A: F_{Direct} \neq F_{Indirect}$	W=151.000	0.597

It was also possible to observe that there is no statistically significant difference ($\chi^2_{(2)}$=1.114; p=0.573) in the eco-design implementation index distribution between the three different groups of education degree (University, n=19; High School, n=8; Basic Education, n=6).

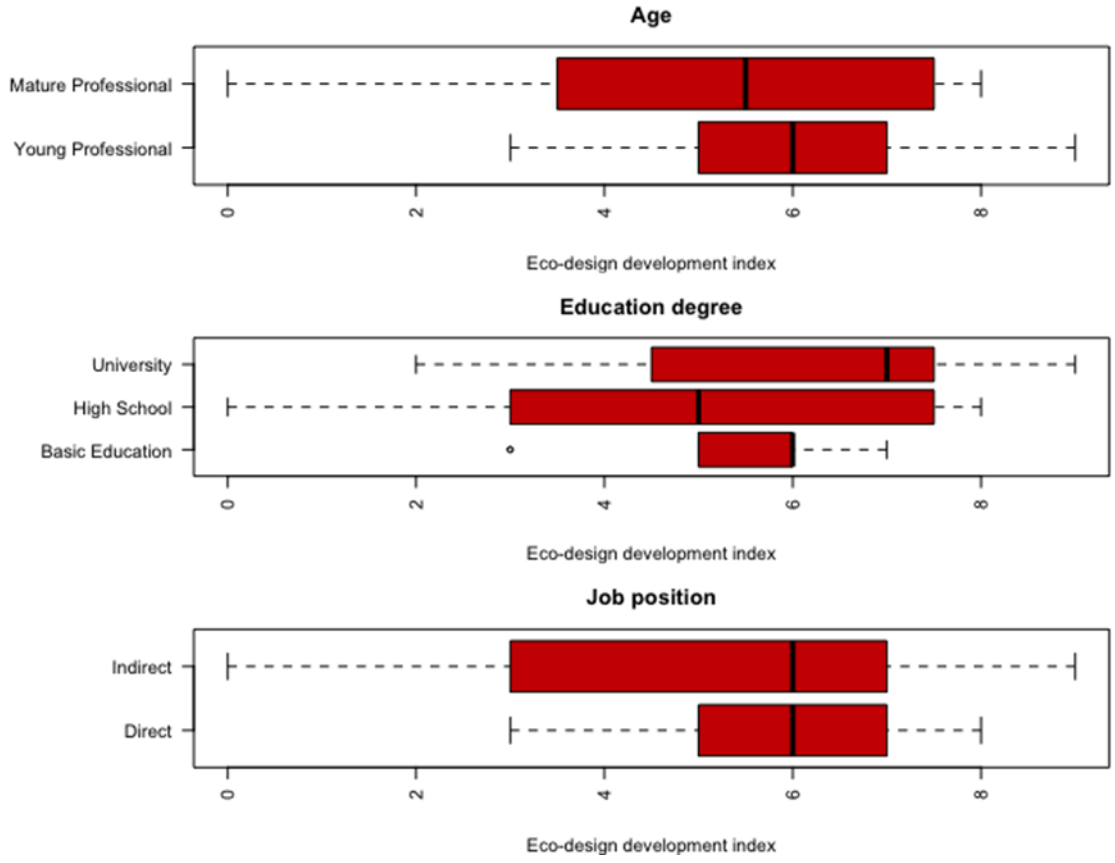

Figure 34 - Parallel boxplot for eco-design implementation index according to the levels of age, education degree and job position of the respondent.

Investigation Hypothesis H_2

To study if the company's characteristics could be a key figure for the implementation of eco-design by being statistically related to the index of eco-design implementation, a second hypothesis was tested:

$\boldsymbol{H_0}$: The company characteristics do not influence the eco-design implementation in the company.

Vs

$\boldsymbol{H_A}$: The company characteristics influence the eco-design implementation in the company.

The effect of company age, location, number of employees, business volume, innovation development and industrial association partnership on eco-design implementation index were tested with Kruskal-Wallis and Mann-Whitney tests. The table 10 shows the results of the tests and the figure 35 summarizes eco-design implementation index values across the levels of these six factors.

Table 10 - Test results for H_2.

Variables	Hypotheses	Test statistic	p
Company age	$H_0: F_{New} = F_{Mature} = F_{Experienced}$ H_A: At least one of the populations tends to yield larger observations than at least one of the other populations	$\chi^2_{(2)}$=1.824	0.402
Location	$H_0: F_{North} = F_{Center} = F_{South}$ H_A: At least one of the populations tends to yield larger observations than at least one of the other populations	$\chi^2_{(2)}$=0.013	0.994
Number of employees	$H_0: F_{Large} = F_{Medium} = F_{Small}$ H_A: At least one of the populations tends to yield larger observations than at least one of the other populations	$\chi^2_{(2)}$=1.199	0.549
Turnover 2017	$H_0: F_{Large} = F_{Medium} = F_{Small}$ H_A: At least one of the populations tends to yield larger observations than at least one of the other populations	$\chi^2_{(2)}$=0.882	0.644
Innovation development	$H_0: F_{Yes} = F_{No}$ $H_A: F_{Yes} \neq F_{No}$	W=38.000	0,276
Industrial association partnership	$H_0: F_{Yes} = F_{No}$ $H_A: F_{Yes} > F_{No}$	W=100.5	0.202

According to the tests, the company age ($\chi^2_{(2)}$=1.824; p=0.402), which divides the data into three groups (New companies, n=14; Mature companies, n=6; Experienced companies, n=13), and its location ($\chi^2_{(2)}$=0.013; p=0.994), on the North (n=11), Centre (n=17) or South (n=5) of Portugal, do not have any influence on the eco-design implementation on the company, neither does the number of employees ($\chi^2_{(2)}$=1.199; p=0.549), that was categorized into three groups (Large, n=3; Medium, n=21; Small, n=9).

The turnover of the company in 2017 ($\chi^2_{(2)}$=0.882; p=0.644), which divides the companies into three categories (Large, n=7; Medium, n=12; Small, n=14) also does not have any proven influence in the eco-design implementation.

The existence of innovation development predisposition in a packaging manufacturer does not allow to conclude that this is statistically related to eco-design implementation in the company (W=38.000; p=0.276).

Although industrial associations partnership may be seen as a key factor for the environmental development of companies, it was not possible to conclude it (W=100,5; p=0,202).

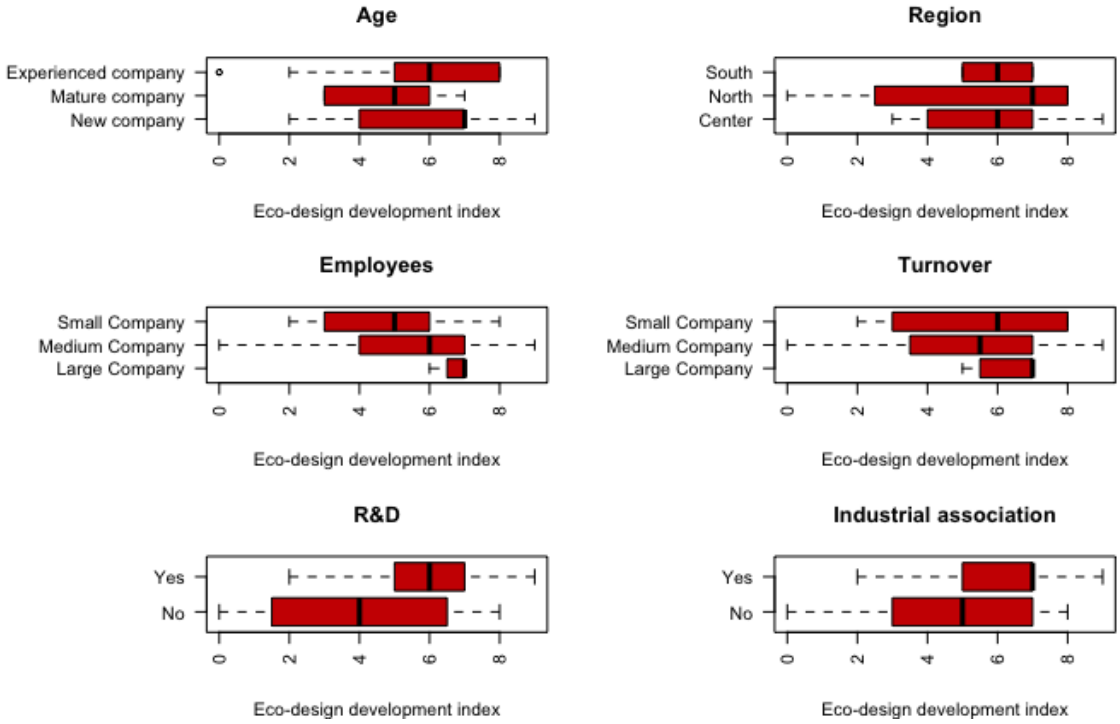

Figure 35 - Parallel boxplot for eco-design implementation index according to the company age, location, number of employees, 2017 turnover, innovation development and industrial association partnership.

Investigation Hypothesis H_3

To check the importance of the supply chain department for the eco-design in a company, a third investigation hypothesis was tested in this study:

$\boldsymbol{H_0}$: The age, the education degree and the decision factors of supply chain responsible do not influence the eco-design implementation in the company.

Vs

$\boldsymbol{H_A}$: The age, the education degree and the decision factors of supply chain responsible influence the eco-design implementation in the company.

The influence of the supply chain responsible age, education degree and its purchase decision factors (quality, durability, lead time, materials sustainability, purchasing cost, shelf life, supplier certification ISO 14001 and EMAS) in the eco-design development was verified through the statistical tests Kruskal-Wallis and Spearman coefficient. On table 11 it is possible to observe the test results and on figure 36 the eco-design implementation index is summarized into the different variables.

Table 11 - Test results for H_3.

Variables	Hypotheses	Test statistic	P
Supply Chain Responsible Age	$H_0: F_{<40years} = F_{40\geq years}$ $H_A: F_{<40years} \neq F_{40\geq years}$	W=155.5	0.272
Education degree	$H_0: F_{High} = F_{Graduate}$ $H_A: F_{High} \neq F_{Graduate}$	W=83.5	0.156
Purchase decision factor: Quality	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.255$	0.153
Purchase decision factor: Durability	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.227$	0.,205
Purchase decision factor: Lead Time	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.069$	0.701
Purchase decision factor: Materials Sustainability	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.315$	0,074
Purchase decision factor: Purchasing cost	$H_0: \rho = 0$ $H_A: \rho \neq 0$	r_s =0.009	0.957
Purchase decision factor: Shelf life	$H_0: \rho = 0$ $H_A: \rho \neq 0$	r_s =0.347	**0.048***
Purchase decision factor: Supplier certified ISO 14001 and EMAS	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.555$	**<0.001***
Purchase decision factor: Supplier reputation	$H_0: \rho = 0$ $H_A: \rho \neq 0$	r_s =0.470	**0.006***

* Statistically significant positive correlation at the 0.05 level.

According to the results achieved, both age (W=155.5; p=0.272) and education degree (W=83.5; p=0.156) of the supply chain responsible do not influence the eco-design development in the company. While some purchasing factors do not have statistical correlation in the eco-design development index, such us quality (r_s=0.255; p=0.153), durability (r_s=0.227; p=0.205), lead time (r_s=0,069; p=0.701), materials sustainability (r_s=0.315; p=0.074) and purchasing cost (r_s=0.009; p=0.957), others have significant positive correlation, such as shelf life (r_s=0.347; p=0.048), supplier certification in ISO 14001 and EMAS (r_s=0.555; p<0.,001) and supplier reputation (r_s=0.470; p=0.006).

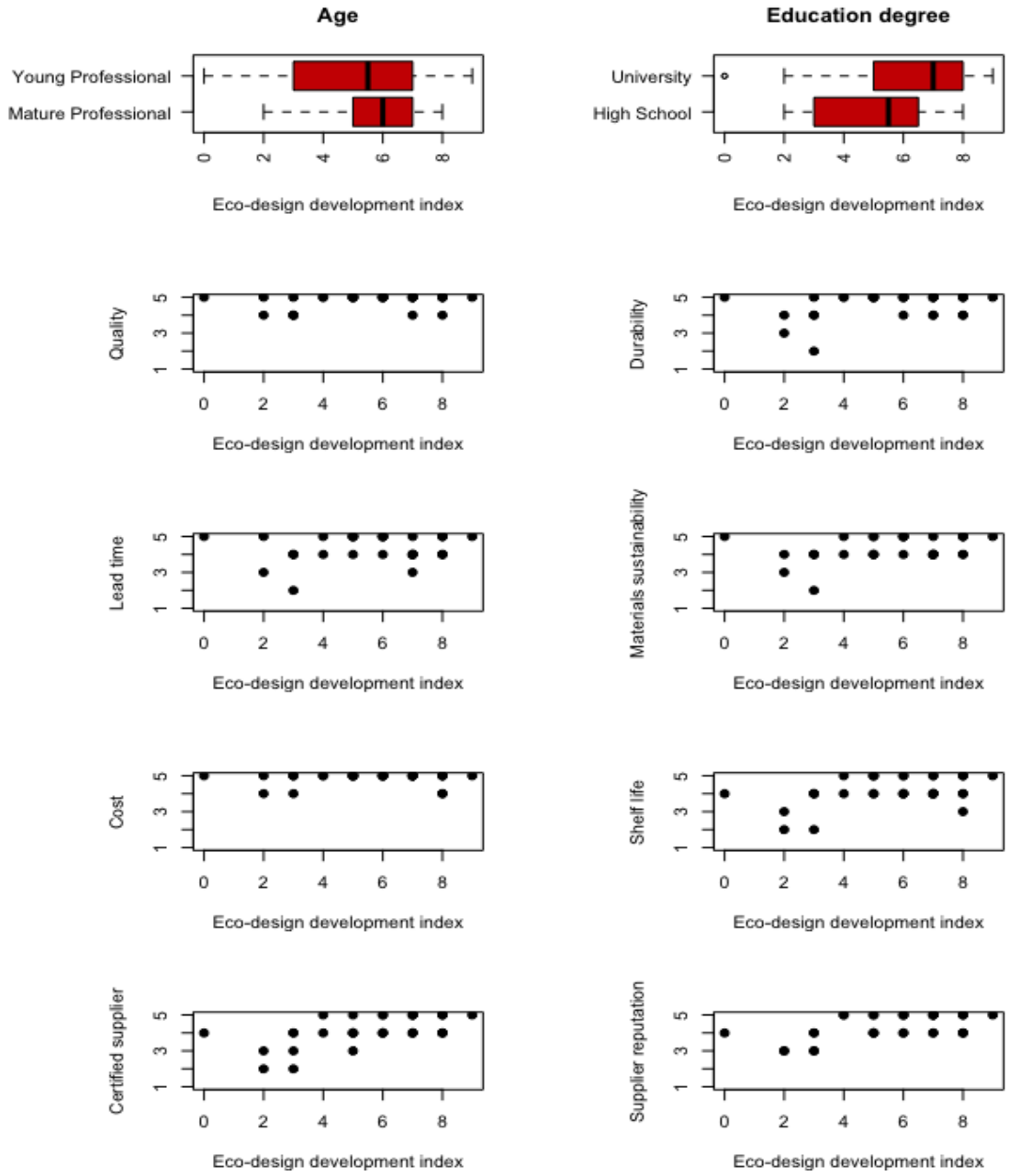

Figure 36 - Graphs of the Investigation Hypothesis H_3.

Investigation Hypothesis H_4

With the environmental characterization of the company done, it was important to check if it had any kind of statistical correlation with the eco-design index, therefore a fourth investigation hypothesis was tested:

$\boldsymbol{H_0}$: The Environmental mindset and awareness of the administration and employees do not influence the eco-design implementation in the company.

Vs

$\boldsymbol{H_A}$: The Environmental mindset and awareness of the administration and employees influence the eco-design implementation in the company.

The classification of the environmental impacts, the recommendation to the customer of ecologically sustainable packaging and the importance of the internal environmental policies impacts on the company's socioeconomic success were tested with Mann-Whitney tests and Spearman coefficient to check their influence on the eco-design development index. The results of these tests are presented in table 12 and in figure 37 the eco-design development index is summarized.

Table 12 - Test results for H_4.

Variables	Hypotheses	Test statistic	P
Environmental impact: 100% recycled packaging	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.495$	**0.003***
Environmental impact: weight of the packaging	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.306$	0.083
Environmental impact: paint used on the packaging	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.287$	0.105
Environmental impact: energy used on the process	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.036$	0.841
Environmental impact: packaging ease to collapse	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.362$	**0.039***
Recommendation to the customer of ecologically sustainable packaging	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.231$	0.196
The socioeconomic success relies directly on the internal environmental policies	$\mathrm{H_0}: \mathrm{F_{Yes}} = \mathrm{F_{No}}$ $\mathrm{H_A}: \mathrm{F}_{Yes} \neq \mathrm{F_{No}}$	W=49.500	0.309

* Statistically significant positive correlation at the 0.05 level.

As can be seen on the table, there are two aspects that can be highlighted as positively correlated with the eco-design index - the importance given to the environmental impact: 100% recycled packaging (r_S=0.495; p=0.003) and the environmental impact: packaging ease to collapse (r_S=0.362; p=0.039).

Although the importance of two environmental impacts is connected to the index, the others do not have any correlation with it. The weight of the packaging (r_S=0.306; p=0.083), the paint used on it (r_S=0.287; p=0.105) and the energy used on the process (r_S=0.036; p=0.841) are not features that are statistically correlated with the eco-design development index.

Surprisingly, the recommendation to the customer of ecological sustainable packaging (r_S=0.231; p=0.196) and the impact of internal environmental policies for the socioeconomic success of the manufacturer (W=49.500; p=0.309) do not have a statistical influence on the index.

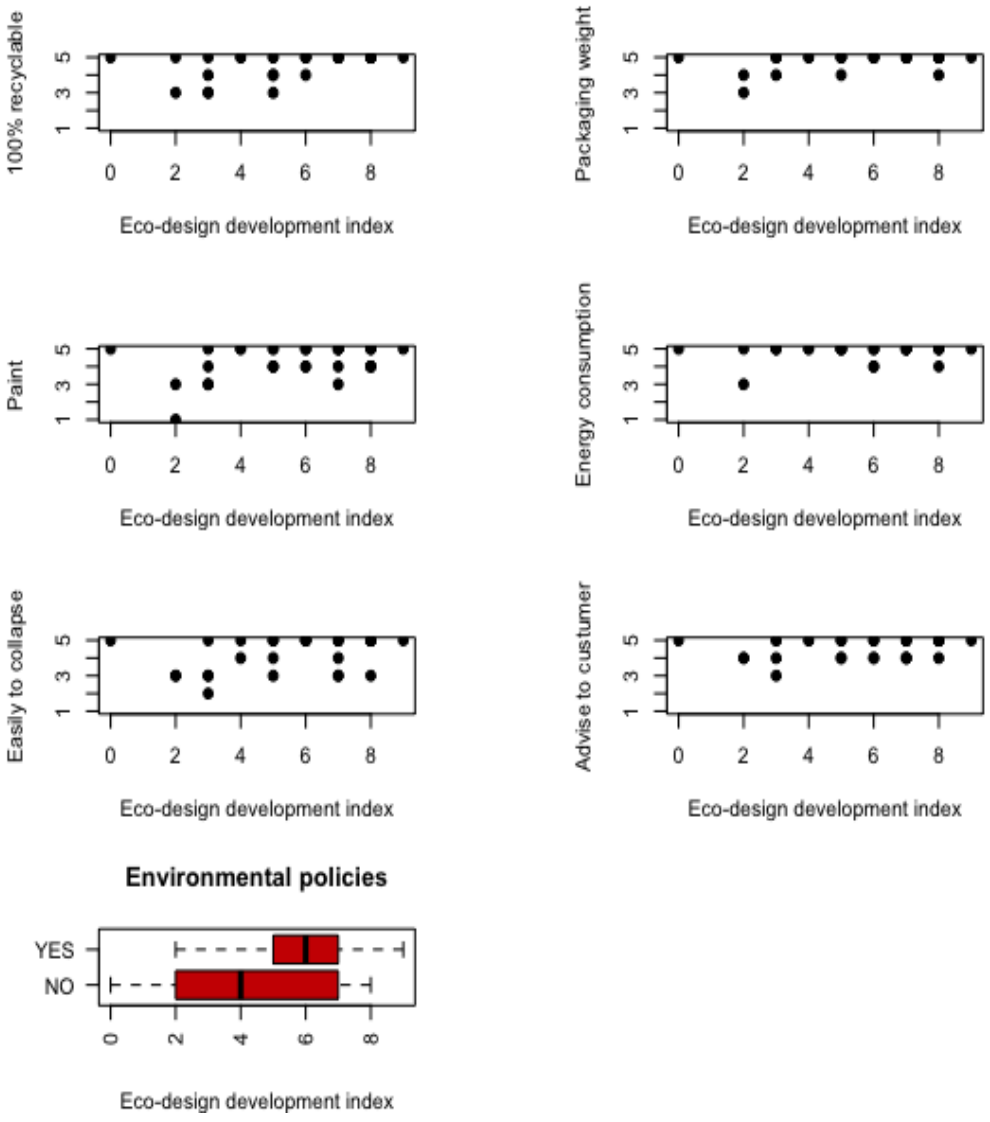

Figure 37 - Graphs of the Investigation Hypothesis H_4.

Investigation Hypothesis H_5

The environmental innovation predisposition was tested on the fifth investigation hypothesis, trying to find any sights of statistical correlation between it and the eco-design development index:

H_0: The company environmental innovation predisposition does not influence the eco-design development in the company.

Vs

H_A: The company environmental innovation predisposition influences the eco-design development in the company.

Mann-Whitney test and Spearman Coefficient were also used to verify the existence of the influence of diverse environmental variables in the eco-design development in the company. Table 13 shows the results of the tests and in figure 38 is possible to analyse the graphs for all the variables tested.

Table 13 - Test results for H_5.

Variables	Test hypotheses	Test statistic	P
Company willingness for product innovation	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.601$	**<0.001***
The existence of the R&D department in a company	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.085$	0,637
Innovation in products usage	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.201$	0.261
Optimization of packaging shape	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.335$	0.065
Improvement in manufacturing processes	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.095$	0.598
Eco-innovation processes in the packaging industry	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.210$	0,241
University and research partnerships	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.103$	0.568
Government incentives to sustainable materials	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.026$	0.887
Government incentives to sustainable materials	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.024$	0.894
Company improvement in environmental impacts	$H_0: F_{Yes} = F_{No}$ $H_A: F_{Yes} > F_{No}$	W=47.5	**0.027***
Importance of eco-design	$H_0: \rho = 0$ $H_A: \rho \neq 0$	$r_s = 0.554$	**<0.001***

* Statistically significant positive correlation at the 0.05 level.

By analysing the results, it can be verified that there are three environmental variables that have correlation or influence the eco-design development index. In fact, the company willingness for product innovation (r_S=0.601; p<0.01) and the importance given to eco-design by respondents (r_S=0.554; p<0.01) have a positive moderated correlation with the index.

The company improvements in environmental impacts also influence the development of eco-design in packaging manufacturers (W=47.5; p=0.027). All the other tested variables do not appear to have statistical influence in the index, according to the data presented on the table.

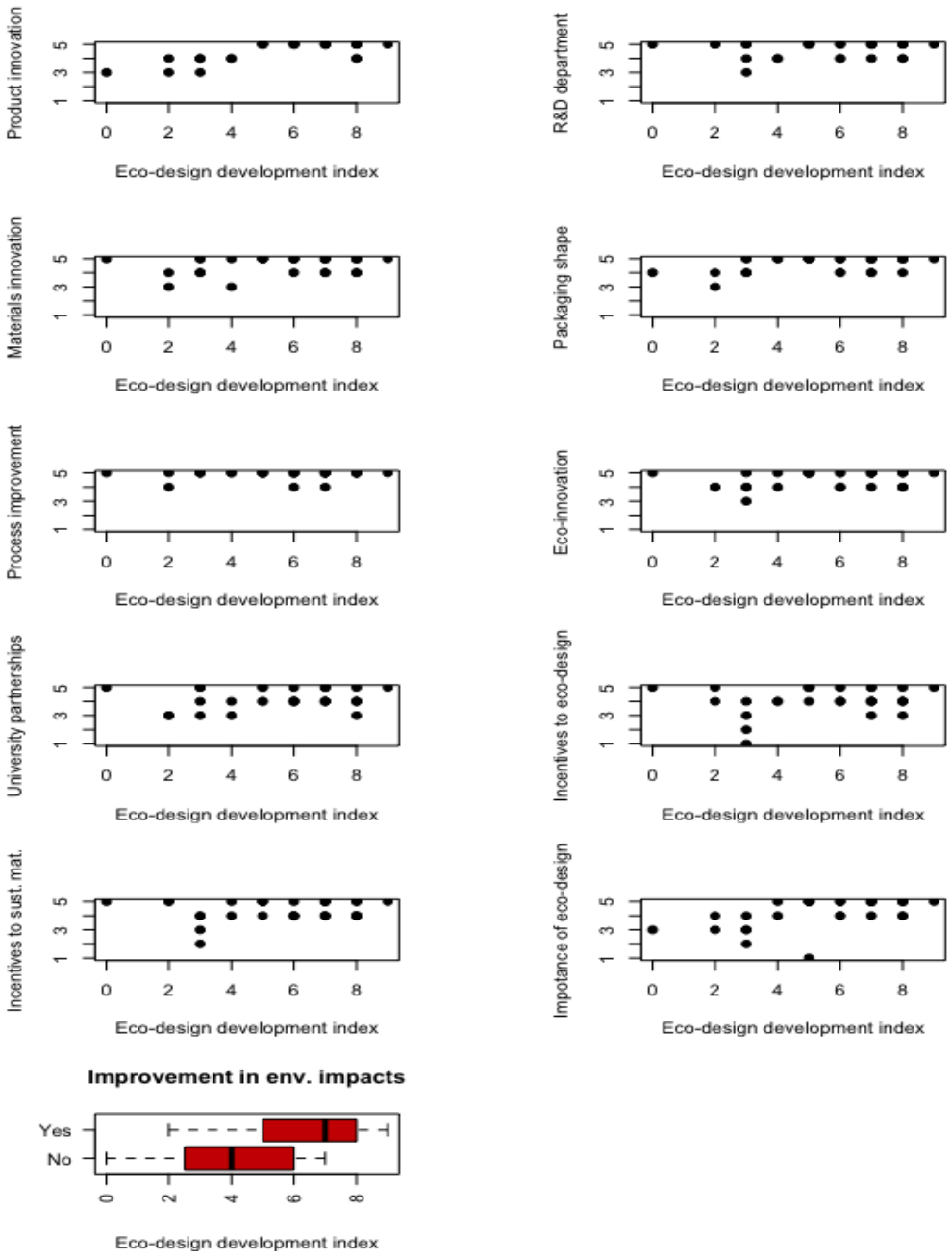

Figure 38 - Graphs of the Investigation Hypothesis H_5.

3.8 Exploited Conclusions

After having classified the companies into an eco-design index and tested all the investigation hypothesis that faced the general and the specific objectives it is possible to say that eco-design is not a reality for all packaging manufacturers.

In fact, 30% of the manufacturers had a score equal to or smaller than four in the eco-design index, showing that they do not have any kind of ecological culture in-house.

It was also possible to conclude that some purchasing factors such us shelf life of materials, certified suppliers and the supplier's reputation are variables that are correlated with the eco-design development in companies. This means that packaging manufactures with ecological thinking have a clear preference for suppliers that assure materials with large shelf life in order to prevent unnecessary waste but also for suppliers that are certified by ISO 14001 and registered in EMAS assuring that these companies have an environmental management system and promote the continuous improvement in environmental performance. Inevitably these suppliers have a great reputation on the market making them natural choices for ecological packaging manufacturers.

The attention paid to the environmental impacts of the produced packages is also related to the eco-design development in companies, as the 100% recyclability and easiness of collapse for disposal appeared as variables that are present in the best-rated eco-design development companies.

Finally, it was concluded that the company willingness for product innovation and the company improvements in environmental impacts is related to the development of eco-design in the companies. As expected the importance that packaging manufactures give to eco-design is also a variable that influences the development of it into the companies.

3.9 Recommendations for the Portuguese Packaging Industry

Portuguese packaging manufacturers seem not to be completely aware of the importance of several industrial practices for the environmental performance.

Most of the companies have more than 30 years old and 48% do not belong to any industrial association which means that most of them are experienced manufactures but do not have any interest in developing industrial networking in order to achieve better ecological performances. Therefore, it is recommendable for manufacturers to get together and have an active role in achieving the environmental goals that Portugal is committed with, by improving the processes and being ecological in product development.

It would also be important to create a general packaging association in Portugal. The industrial organizations that exist are organized by packaging materials and do not have goals in common, leading to the lack of organization and to the duplication of efforts. Countries such as Brasil and the United States have packaging industrial associations that cover all packaging materials and have a global goal that unifies the manufacturers. They develop training and make available tools that allow associates not only to comply the environmental legislation but also have the best-practices when it comes to environmental performance.

Packaging suppliers should also pay more attention to the memorandums of international governmental organizations because the communications of today are the laws of tomorrow. Being prepared on time is crucial for the company success and the current Portuguese reality is not favourable, as 48% of companies are not certified in ISO 14001 and 76% are not registered in EMAS, making them highly exposed and not prepared for more strict laws.

To prepare the environmental challenges of the future and to be competitive in a market where customers are more and more demanding when it comes to environmental impacts it is recommendable for manufacturers to develop internal policies and have key performance indicators that allow them to keep the ecological sustainability of the company.

CONCLUSIONS

4 CONCLUSIONS AND FUTURE WORK PROPOSALS

4.1 Conclusions

This piece of work was developed to analyse the environmental awareness and commitment of the Portuguese packaging manufactures while designing and producing a new package.

To better understand the evolution of packaging through the years and the environmental impacts associated with it, it was necessary to develop a bibliographic research. In fact, it was also necessary to research the amount of packaging manufactures present in Portugal.

In Portugal, there are 641 packaging manufacturers. With the support of APIGRAF some companies were identified and invited to take part in the study by answering a questionnaire that was distributed by email. From the companies surveyed, 66% answered the questionnaire successfully.

The results of the survey made it possible to direct support the study and the creation of data, so it would be possible to interpret, discuss, and transform them into variables for the test of the necessary hypothesis that was carried out in this piece of work.

The majority of the answers were from the centre of Portugal with 52% of the answers, followed by the north region with 33%. From Madeira and Azores, no responses were obtained.

Through the analysis of the results it was possible to conclude that, generally, the companies revealed some awareness for the environmental issues, as 85% of them believe that the socioeconomic success of the company is related to the environmental policies and their application in the processes and product design, and in 94% of the customers are guided to purchase a more ecological packaging solution.

But, when it comes to giving the next step on ecological management, Portuguese packaging producers reveal that they are not interested in investing on it. Only 52% are ISO 14001 certified and, surprisingly, only 24% are registered in the EMAS. Then it is possible to conclude that the manufacturer's environmental concerns are not real, because their perception is not according to the company practices.

Although 73% of the companies say that there's an eco-design culture in companies it was not possible to conclude that there was a correlation between it and the age, education degree and professional success of the employees. Regarding the

companies' characteristics, it was also not possible to conclude that any variable was statistically related to eco-design development.

When it comes to the supply chain department and it's purchasing factors it is possible to conclude that companies that are cared about the materials shelf-life have a better eco-design development in-house. More than 80% of the companies said that having a reputed supplier certified with ISO 14001 and registered in EMAS was very or extremely important, and it was possible to conclude that these factors are related to eco-design development in the company.

The importance given to the recyclability of the package and the easiness of collapse are the environmental impacts that show a relation with the development of eco-design in companies. Surprisingly, it was not found a correlation between it and the weight and the paint of a package.

Finally, it is clear that the lack of practices and preparation for the current environmental issues of the world might be a threat to the industry in Portugal. Without a global packaging association to spread knowledge, competences and give modernization support, and with companies not showing interest in ecological self-development, the competitiveness of the companies might be affected in the future.

It is expected that governmental entities will create more restricted laws to accomplish the international environmental goals. Only companies that truly have environmental management systems and that are improving their packages' environmental impacts through the introduction of eco-design are going to have a competitive advantage.

In general, it can be said that the surveyed companies still have a long way ahead of them to improve their environmental and sustainable practices, and to introduce eco-design as a tool for competitiveness in a world where environmental sustainability is becoming a purchasing factor. When it comes to the environmental innovation predisposition, companies willing for product innovation and that improve constantly their environmental impacts have a stronger eco-design implementation.

4.2 Future Studies Proposals

In this study, the sample size was a limitation for the statistical analysis and for the results, therefore it would be interesting to go further and collect data of more packaging manufactures and perhaps find correlations that were not possible in this study.

It is also important to develop further studies regarding the eco-design development in other industries of ecological concern.

BIBLIOGRAPHY AND OTHER SOURCES OF INFORMATION

5 BIBLIOGRAPHY AND OTHER SOURCES OF INFORMATION

5.1 Bibliography

Boucher, J., Evequoz, P., Friot, D., Mayer, S., & Van Lierde, N. (2017). *Adopting a life cycle perspective through ISO14001: a game changer*. OVAM, 2017.

Calver, G. (2004). *What is Packaging Design?: Essential Design Handbook*. F & W Publications.

Crawford, I. M. (1997). *Marketing research and information systems (No. 4).* Food & Agriculture Org..

Decreto-Lei nº 366-A/97 de 20 de Dezembro. Diário da República nº 293 — 20-12-1997— I Série-A. Lisboa: Ministério do Ambiente.

EEA. (2015). *Generation and recycling of packaging waste*. European Environment Agency.

Emblem, A. (Ed.). (2012). *Packaging technology: Fundamentals, materials and processes*. Elsevier.

Endler, D. (2003). *A história e a embalagem*. Top de Embalagem.

Evangelista, J. (1994). Tecnologia de alimentos. São Paulo: Atheneu.

European Commission. (2008). Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste. Official Journal of the European Union L, 312(13), 22-11.

Gil, L. (1990). *Reciclagem dos plásticos do lixo urbano*. INGENIUM

Gonçalves, R. (2017). *Mercado Global de Embalagens Cresce a Ritmo Médio Anual de 3,5% até 2020*. Hipersuper.

G.EN.ESI, Education Centre. (2014). *Introduction to Eco-design*.

Karaski, T., Ribeiro, F., Pereira, B., & Arteaga, L. (2016). *Embalagem e Sustentabilidade: Desafios e Orientações no Contexto da Economia Circular*. São Paulo: CETESB.

Kirwan, M. J. (Ed.). (2008). *Paper and paperboard packaging technology*. John Wiley & Sons.

Lautenschlager, B. I. (2001). Avaliação de embalagem de consumo com base nos requisitos ergonômicos informacionais.

Lee, C. K., Lee, J. Y., Choi, Y. H., & Lee, K. M. (2016). Application of the integrated ecodesign method using the GHG emission as a single indicator and its GHG recyclability. Journal of Cleaner Production, 112, 1692-1699.

MARIANO, M. J., & FROEMIMING, L. M. S. (2008). Considerações sobre a história da embalagem de alimentos: A evolução de uma poderosa ferramenta de marketing. UNIJUÍ. IJUÍ.

Monteiro, A. C. (2016). *Retrato da Indústria da Embalagem em Portugal*. Hipersuper.

Moreno, R. P. R. (2017). *Estudo sobre a incorporação de produtos nocivos ao ambiente no fabrico de tintas.*

NYC. (2017). *NYC Reuse Sector Report.* New York City Department of Sanitation.

Opie, R. (1989). Packaging source book. Macdonald Orbis.

Pearce, D., & Turner, R. K. (1992). *Packaging waste and the polluter pays principle: a taxation solution*. Journal of Environmental Planning and Management.

Pereira, D. F. (2006). *A embalagem como voz comercial do produto/marca*. Faculdade de Engenharia da Universidade do Porto.

Pilditch, J. G. C. (1973). The Silent Salesman. How to Develop Packaging that Sells…. Business Books.

Plastics Europe (2017). *Plastics – the Facts 2017.* Plastics Europe.

Pongrácz, E. (2007). *The environmental impacts of packaging. Environmentally Conscious Materials and Chemicals Processing*.

Rocha, C. (2011). *Manual de Ecodesign*. Innovation and ecodesign in the ceramic industry (InEDIC)

Rodrigues, D., Sá L., Silvestre R., Fagury T. (2010). *Nosso Aço - Uma história para ser contada*. B&B

Silva, A. P. B. D. (2017). *Analysis of the printing industry concerning the use of ecological products.*

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*. Resolution adopted by the General Assembly.

Vieira, C., Alves, J., & Roque, M. (2013). *Manual Prático de Ecodesign.* Associação Empresarial de Portugal (AEP) - Gabinete de Projetos Especiais.

Wilts, C. H., Bahn-Walkowiak, B., & Hoogeveen, Y. (2018). Waste prevention in Europe: policies, status and trends in reuse in 2017.

Yeang, K., & Woo, L. (2010). *Dictionary of ecodesign: an illustrated reference*. Routledge.S

5.2 Web Sites

ABRE (2012). Accessed on 15-03-2018. http://www.abre.org.br/setor/apresentacao-do-setor/a-embalagem/funcoes-das-embalagens/.

CERV (2018). Accessed on 07-01-2018. http://cerv.pt/reciclagem-do-vidro/.

European Aluminium Association (2016). Accessed on 09-01-2018. https://www.european-aluminium.eu/about-aluminium/aluminium-in-use/packaging/.

FEFCO (2018). Accessed on 05-02-2018. http://www.fefco.org/corrugated-packaging/history-corrugated

Plastics Europe (2018). Accessed on 02-02-2018. https://www.plasticseurope.org/en/resources/publications

PLASTVAL (2008). Accessed on 10-02-2018. http://www.plastval.pt/index.asp?info=plastico.

INE (2018). Accessed 27-06-2018. https://www.ine.pt/

ISO (2011). Accessed 05-04-2018. https://www.iso.org/obp/ui/#iso:std:iso:14006:en

APPENDICES

6 APPENDICES

6.1 Questionnaire

Eco-Design in the Portuguese Packaging Industry

João Monteiro, School of Engineering, Polytechnic of Porto

The aim of this study is to analyse accurately the national packaging industry, intending to understand how eco-design and environmental sustainability are faced in the industrial and socio-economic processes of all companies.

The obtained data trough this questionnaire is of great importance for the success of this study, although it is of voluntary participation.
All the answers will be handled confidentially and are going to be used exclusively in this study, not being disseminated or shared for other motives.

If you do not intend to participate, close the page please. When clicking on “next”, you are agreeing to participate in the research and data collecting.

Estimated time for completion of the form: 15 minutes.

Thank you.

isep Instituto Superior de Engenharia do Porto

P.PORTO

I – Interviewed Characterization

1. Age?

2. Education Level?

No education

1st Cycle of Basic Education (4th grade)

2nd Cycle of Basic Education (6th grade)

3rd Cycle of Basic Education (9th grade)

Secondary Education (12th grade)

Higher Education - Graduation

Higher Education - Master

Higher Education - Phd

3. Position in the Company?

Management

Supply Chain & Procurement

Marketing & Sales

Research & Development

Production

Planning & Logistics

Quality

Other. which?

II – Company Characterization

4. Name of the company?

5. Data of foundation?

6. Company Location?

Viana do Castelo

Braga

Vila Real

Bragança

Porto

Viseu

Aveiro

Coimbra

Guarda

Leiria

Castelo Branco

Santarém

Portalegre

Lisboa

Setúbal

Beja

Évora

Faro

R. A. Madeira

R. A. Açores

7. In which field of the Packaging Industry is the company specialized?

Metal

Plastic

Glass and ceramic

Paper and corrugated board

Wood

Other. Which?

8. To which market sector is the company more oriented?

Food

Pharmacy

Automotive industry

Chemical products

Consumer goods

Other. Which?

9. Number of employees of the company?

< 10 employees – Micro-enterprise

>= 10 and <50 employees – Small Company

>= 50 and <250 employees – Medium Company

>= 250 employees – Large Company

10. What was the company's turnover in 2017?

<= 2 million euros – Micro-enterprise

> 2 and <= 10 million euros - Small Company

> 10 and <= 50 million euros – Medium Company

> 50 million euros – Large Company

11. Does the company exports?

No

Yes

a. If Yes, what is the volume of exportation in relation to the total business volume of the company?

<= 25%

> 25 e <= 50%

> 50 e <= 75%

> 75%

12. Does the company have a Research and Development (R&D) department?

No

Yes

13. Is the company registered in any Industrial Association?

No

Yes

a. If Yes, in which?

III – Characterization of Purchasing Department

14. what's the age of the purchasing responsible of the company?

<= 20 years old

21 to 30 years old

31 to 40 years old

41 to 50 years old

51 to 60 years old

> 60 years old

Don't know/No opinion

15. What is the education level of purchasing responsible?

No education

1st Cycle of Basic Education (4th grade)

2nd Cycle of Basic Education (6th grade)

3rd Cycle of Basic Education (9th grade)

Secondary Education (12th grade)

Higher Education - Graduation

Higher Education - Master

Higher Education – Phd

16. Classify according to the importance the decision factors for the purchasing of products and/or raw materials: (1 – Unimportant; 2 – Somewhat important; 3 – Important; 4 – Very Important; 5 – Extremely Important)

Quality

Durability

Lead Time

Materials Sustainability

Purchasing cost

Shelf Life

Supplier certified with ISO 14001 and registered in EMAS

Supplier reputation

IV – Environmental Characterization of the Company

17. Is there a culture focused on Eco-Design on the company?

No

Yes

18. Does the company gives systematic training in environmental responsibility, sustainability and Eco-Design?

No

Yes

a. If Yes, how frequently?

Once every 3 months

Once every 6 months

Once every year

Once every 2 years

Other frequency. Which?

19. In terms of environmental impact, how do you classify each aspect?

(1 – Unimportant; 2 – Somewhat important; 3 – Important; 4 – Very Important; 5 – Extremely Important)

100% Recycled Packaging

Weight of the Packaging

Paint used in the Packaging

Energy used on the Process

Packaging ease to collapse (for storage and transporting)

20. Is the company certified by the norm ISO 14001?

No

Yes

21. Is the company registered in the Eco-Management and Audit Scheme (EMAS)?

No

Yes

22. How important is the recommendation to the customer of ecological and/or more sustainable packaging? (1 – Unimportant; 2 – Somewhat important; 3 – Important; 4 – Very Important; 5 – Extremely Important)

23. Does the marketing and/or sales department guides, somehow, customers the acquire more ecological packaging?

No

Yes

24. Is the environmental impact of packaging waste monitored somehow?

No

Yes

a. If Yes, how?

25. Does the company have KPIs to evaluate the sustainability evolution of their products over time.

No

Yes

a. If Yes, specify.

26. Do you believe that the socioeconomic success of the company relies directly on the internal environmental policies and the application of them on the process and/or products?

No

Yes

V – Characterization of the Product Development

27. How do you classify the predisposition for product innovation in the company? (1 – Not innovative; 2 – Somewhat innovative; 3 – Innovative; 4 – Very Innovative; 5 – Extremely Innovative)

28. Classify according to the importance the following aspects: (1 – Unimportant; 2 – Somewhat important; 3 – Important; 4 – Very Important; 5 – Extremely Important)

Existence of R&D department in a company

Innovation in products usage (raw materials and/or packaging parts)

Optimization of packaging size

Improvement in manufacturing processes

Introduction of Eco-Innovation processes in the Packaging Industry

Establishment of partnerships with education and/or research institutions

Creation of legislation to limit the ecological footprint of a package

To promote the utilization of sustainable materials trough the governmental actions

29. Do you believe that your company tries, constantly, improve the environmental impacts of the products?

No

Yes

a. If Yes, how?

30. How important is Eco-Design? (1 – Unimportant; 2 – Somewhat important; 3 – Important; 4 – Very Important; 5 – Extremely Important)

6.2 Questionnaire Validations

6.2.1 Bosch Car Multimedia Validation

FW: Dissertação de Mestrado Eco-Design na Industria da Embalagem - ISEP|PPorto

Sousa Pauloalexandre (CM/LOD) <PauloAlexandre.Sousa@pt.bosch.com>

qua 21-02-2018 17:13

Para:João Monteiro (1110485) <1110485@isep.ipp.pt>;

1 anexos (502 KB)

QuestionárioV3.pdf;

Boa tarde João,

Estive a analisar o questionário enviado, e na minha opinião está ok.

Obrigado,

Cumprimentos / Best regards,

Pauloalexandre Sousa
CM/LOD

Tel. +351 253 306771

6.2.2 Calheiros Embalagens Validation

RE: Dissertação de Mestrado Eco-Design na Industria da Embalagem - ISEP|PPorto

Marcelo Azevedo <marcelo.azevedo@calheiros.pt>

qua 21-02-2018 10:52

Para:João Monteiro (1110485) <1110485@isep.ipp.pt>;

Ex.mo Sr. João Monteiro,

Após análise do inquérito enviado, venho por este meio validar o mesmo.

As questões apresentadas são adequadas para atingir o objetivo descrito no email abaixo.

Com os melhores cumprimentos,

Marcelo Azevedo
Planeamento e Controlo Produção

6.2.3 APIGRAF Validation

RE: Dissertação de Mestrado Eco-Design na Industria da Embalagem - ISEP|PPorto

JL Jorge Lopes <jorge.lopes@apigraf.pt> Responder a todos
ter 27-02, 15:10
João Monteiro (1110485)

Inbox

Boa tarde, João Monteiro.

O questionário vai de encontro aos objetivos.

Deverá ter em atenção a facilidade de preenchimento do mesmo, uma vez que é um pouco longo.

Com os meus melhores cumprimentos.

Jorge Lopes
Gabinete de Atividades Comerciais e Associativas
apigraf
Associação Portuguesa das Indústrias Gráficas e Transformadoras do Papel

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