INNOVATIVE PACKAGING DESIGN
Toothpaste packaging design case study.

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A thesis submitted for the degree of Master of Science (MSc) in Strategic Product Design
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I hereby declare that the work submitted is mine and that where I have made use of another’s work, I have attributed the source(s) according to the Regulations set in the Student’s Handbook.

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Abstract

This dissertation was written as part of the MSc in Strategic Product Design at the International Hellenic University.

Oral care products and especially toothpastes, are vital for the human daily hygiene. Nowadays tooth brushing is, without a doubt, an integral part of preventative dentistry, but on the other hand the extensive use of toothpastes has a great impact on the environment. Traditional toothpaste tubes have many negative aspects, in terms of usage and recycling. Their modest size, mixed and merged materials and remnant toothpaste inside toothpaste tubes and other tube based containers, make them difficult to disassemble and recycling almost impossible.

The main objective of this thesis, is to investigate the disadvantages of the toothpaste packaging and the proposal of new innovative packaging solutions, which will not only eliminate the environmental impact that traditional toothpaste tubes cause, but is also user-friendly, too.

Keywords: toothpaste, packaging, product, design, methodology, branding, sustainability

Malea Anastasia

31/03/2017
Στο σημείο αυτό θα ήθελα να ευχαριστήσω τον καθηγητή μου, Δρ. Παναγιώτη Κυράτση για την εμπιστοσύνη που μου έδειξε αλλά και για την ευκαιρία να ασχοληθώ με ένα θέμα ιδιαίτερα δημιουργικό το οποίο αποτέλεσε πρόκληση για εμένα, όπως επίσης και για την πολύτιμη καθοδήγησή του σε όλα τα στάδια της εργασίας.

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1. Introduction

Oral care products and especially toothpastes, are vital for the human daily hygiene. Nowadays tooth brushing is, without a doubt, an integral part of preventative dentistry, but on the other hand the extensive use of toothpastes has a great impact on the environment. Traditional toothpaste tubes have many negative aspects, in terms of usage and recycling.

Their modest size, mixed and merged materials and remnant toothpaste inside toothpaste tubes and other tube based containers, make them difficult to disassemble and recycling almost impossible.

1.1 Initial Review of the Literature and Key References

The literature concerns initially, identifying and analyzing the design problem and is based on an extensive online research of publications, about the problems of recycling of the current toothpaste tubes, as well as the size of the market on oral care products. Subsequently, in order to analyze the packaging design process, a series of books and papers will be studied, presenting issues about packaging design based on specific case studies. Moreover, the literature deals with topics on the design methodology in general and more specifically and addresses issues such as marketing, consumer behavior, cognitive science, sustainability, semantics, ergonomics and design engineering. Finally, in a first phase, the tools which will contribute to the processing of the expected results, will be explored.

1.2 Research Questions

The most important questions which may arise through this survey are the following:

1. What are the problems of the current commercial packaging solutions of oral care products?

2. Is there a need for a new packaging design for tooth paste products?

3. Which materials are recyclable and what properties do they have in order to be applied to the proposed design?
4. To what extent the brand influences the morphological, aesthetical, ergonomic and sustainable features of a package?

5. Which is the environmental impact of the proposed design?

6. What manufacturing method can be used according to the selected materials?

1.3 Research Design & Methodology

The research mainly focuses on the current market to explore problems around the recycling process. Additionally, factors such as new design trends and the design process will be examined in order to obtain a new innovative proposal.

1.4 Contribution and Expected Outcomes

The main objective of this thesis, is to investigate the disadvantages of the toothpaste packaging and the proposal of a new packaging solution, which will not only eliminate the environmental impact that traditional toothpaste tubes cause, but is also user-friendly, too. After a brief marketing research of toothpaste market and the presentation of the new packaging designs, an environmental analysis will be performed in Solidworks Sustainability, in order to select the most sustainable materials and the most sustainable manufacturing method suitable for the specific design.

1.5 Structure of the Dissertation

The chapter two includes an overview on the history of the toothpaste tubes, which dominate the market today, in order to explore the negative points of the particular package and identify the design problem. Through the research into the design process of the packaging, which takes place in the third chapter and deals with issues such as consumer behavior, morphology, aesthetics, ergonomics and sustainability, a design methodology may arise. Last but not least, the forth chapter will present various conceptual proposals according to the design requirements which resulted from the survey, while the environmental impact will be investigated, in order to find the most appropriate materials.
2. Research and Analysis for the Identification of the Design Problem

This chapter is an extensive research on the packaging of the toothpaste industry. After a brief historical review and consideration of the reasons underlying the evolution to acquire the form it has today, the analysis focuses on human centered and sustainable approaches to identify the need of designing a new packaging and record all potential problems so that to define the design problem.

2.1 A Brief History of Toothpaste and packaging

Oral hygiene, concerned from ancient times, various civilizations, with the first form of toothpaste making its appearance in Egypt, in 2000 BC. Consisting of pumice powder and vinegar, this formula although whitened the teeth, caused damage to the enamel. Other variants of toothpaste, created by Greeks and Romans, who observed that the urine, which contain ammonia, component which also exists in modern toothpaste, combined with abrasives, such as crushed bones, shells, charcoal and bark, could freshen the breath and had the form of a chew stick. Later, although the Persians (1000 BC) gradually realized the negative aspects of hard abrasives, they used burnt horn, crushed snail shells, gypsum, flint, and honey instead. In Europe of the Middle Ages, the role of the dentist had the barber-surgeon, who used nitric acid, resulting in white teeth, but short lifespan.

The first efforts to create a dentifrice that effectively protected the health of teeth, took place around 1800, when British chemists, who mixed bicarbonate of soda, a nonabrasive whitener, and strontium, for strengthening action. Momentous enough was also the observation of doctors from Naples, in 1802, that the high fluoride concentration in the water of the area, significantly reduced the cavities, and as a result, fluoride added into the water in 1940, while in 1956 Procter & Gamble integrated it in toothpaste by advertising “Crest with Fluoristan”. (Patrick et al., 2009)

It took a long time for the packaging of the toothpaste to obtain the form it has today and until 1892 tooth powders were available on the market in flat round tins and jars.
On the other hand, metal tubes started to become particularly popular in the art world when the American artist John Rad, designed it during his apprenticeship as a medium that offered comfort to the process of grinding and mixing pigments. In 1841, he patented it and the following year he set up a production system for extruded tubes made of soft metal such as lead and tin, as the price of aluminum was at the same levels as silver. The design remains the same even today, like the thread on the neck and the nozzle. The popularity of the tubes immediately skyrocketed in Europe, since they marked the beginning of prefabricated art supplies. Great Britain had the monopoly of their construction, and introduced it in less industrialized countries such as the US. Later they started to be adopted in a variety of uses such as food and ointments.

The packaging of toothpaste acquires its present form half a century after the discovery of the metal tube. Meanwhile, a pharmacist from Connecticut, Dr Washington Wentworth Sheffield, had already invented in 1850 a more sophisticated toothpaste. So in the early 1890s, his son Lucius Tracey Sheffield, a student in dental school of Paris, after observing the artists who were using paints in tubes, proposed to his father, a more convenient form of packaging for his

Figure 1: Dr. Sheffield’s Dentifrice in a tube. Advert from 1909 and 1908 at the American Magazine. 
(Source: www.connecticuthistory.org, www.stevehollier.wordpress.com )
toothpaste. (Morris, 2011) Advertisements of Dr. Sheffield’s Crème Dentifrice of that era, are shown in Figure 1.

![Figure 1: Advertisement of Dr. Sheffield’s Crème Dentifrice](image)

Although most of the sources give the credits for the invention of the toothpaste tube in Sheffield, the patent shown in the figure above, debunks it, since Foster appears to have patented it earlier.

Immediately the idea was shared among other cosmetic and toothpaste companies and gradually improvements such as printing and embossing took place.

Today, metal tubes are manufactured in an impact extrusion press which extrudes a ductile material such as aluminum or occasionally tin into a neck die and concurrently extrudes it up the sides of a press to form the tube body. The extrusion is trimmed and annealing is essential to soften the material so that it can collapse without cracking. Printing can be carried out before the filling of the tube with the product and the use of flexible coatings is necessary, while the application of the label can also be done after, although it is difficult. After filling the tube, the end is wrapped in a roll and dashed using a matrix which adds date and product code. Screw caps, dispensers or other components are subjoined before reflation, for tubes with open neck, and after on products that for opening require puncturing a seal in the neck. In
some cases an inner coating is necessary to protect the interaction of the product with the metal. Usually though, for the reactive products, plastic or laminated tubes are used, a detailed report of which is in the next chapter. (Morris, 2011)

2.2 Market Research

The growing awareness of oral hygiene, product innovation in new market segments and the frequency of launching in existing segments, have led to a large increase in sales in major markets worldwide. As a result, the toothpaste market is regarded as one of the most dynamic parts in the oral hygiene market.

According to data from Global Industry Analysts, in 2012, Europe is considered to be the largest toothpaste market in the world and its value is estimated to be US$5 billion, with UK having precedence, while Asia Pacific is considered to be the fastest growing market of toothpaste globally, with annual growth rate of over 4%. (Sriram et al., 2013)

In particular for the United Kingdom, the share of the toothpaste market is £330 millions from the total amount of £840 millions, according to research firm Euromonitor.

Figure 3: Oral-B Holographic Printing (Source: www.farmavazquez.com)
As a result, there is a large increase in competition in order to differentiate the toothpaste on the shelves of supermarkets, and manufacturers, according to Euromonitor, have made efforts to turn the toothpaste into high quality product, according to specific dental needs and age groups. Thus packaging options for consumers are countless and clearly upgraded. They range from pump dispensers to aerosols, and brands in order to attract the attention of consumers, they have turned into bright metallic prints with outer cartons to be decorated with foil-blocking and high-color printing and other more special techniques such as embossing and holographic printing that provide more intricate textures(Figure3).

As pointed out by Bob Houghton, marketing manager at Chesapeake Pharmaceutical Packaging, “The majority of cartons are as shiny as possible to achieve stand-out on shelf. These are high-value items, often costing between £3 and £5 – they need to look like they’re worth that. The use of metallic and foiling supports the value of the brand.”

On the other hand, a visit to the supermarket (Figure 4), proves that the industry is still dominated by the tube, a packing device which first appeared in 1892, and despite the efforts for innovation in packaging, consumers do not dare to change their habits, while the competition game is held between GlaxoSmithKline (GSK) and Colgate-Palmolive, companies which have the five leading brands in sales.

Figure 4: Toothpaste Tubes on Greek market shelves (Source: personal archive)
Another demonstration of how slowly this sector evolves, is the adoption of laminate tubes globally. Although today, metal tubes have been eliminated and replaced by polyethylene (PE) or aluminum laminates, it took several decades from their initial launch in 1972 to be established. The exclusive sale of plastic, had Australia in 1983 and began to penetrate into the Chinese market in 1997, when an Indian manufacturer of Essel Propack, started operating there. (Elliott, 2010)

Today the introduction of laminate packaging has increased significantly in many types of packaging apart from the toothpaste, such as coffee packs and pet food pouches, as the benefits that offers compared to the established packages are numerous. Nevertheless, the presence of residual product in combination with the difficult separation of the laminate, makes the recycling process particularly difficult or impossible.

An assessment of the size of the UK market, which is estimated at 193,000 tonnes of packaging annually, containing an average of 97% aluminum foil by weight and the growth rate of laminated packaging in about 10% per year, are sufficient to consider the damage being done to the environment. (Slater et al., 2011)

Below is a comparative analysis of all types of toothpaste packaging that are commercially available with particular emphasis on the positives they offer and the collateral damage.

2.2.1 Metal Tubes

As previously mentioned, until 1981 toothpastes were in the form of powder and they marketed in flat round tins or jars until in the collapsible metal tube first emerged in Great Britain.

One of the positive aspects of the aluminum, is that it is relatively light, malleable, has excellent barrier properties and protects the volatile oils against moisture and flavor loss. They usually have a small diameter re-closable cap of polypropylene. A tube containing 75ml of dentifrice weighs about 8gr with cap weighing approximately 2gr. (INCPEN, 2011)
Compared to plastic tubes they have certain advantages due to lack of “memory”, thereby maintaining coiling at the end. When toothpaste remains near the opening it does not allow air to enter the inner of the tube. A material with “memory”, such as plastic, after the application of pressure, it has a tendency to restore the original form, thus the admission of air that dries the content. (Remington et al., 2006)

On the other hand this can be a disadvantage because the flat sealed edges and sharp corners can destroy or perforate other tubes located beside them. Moreover due to their shape, they are difficult to be stored on the market shelves. The carton box certainly helped both of these problems to be solve, but its necessary existence, additionally burdens the environment. (Stypka et al., 2005)

Technically aluminum collapsible tubes which consist exclusively of one material are recyclable but rarely collected because of the difficulty of removing the toothpaste residue.

Although metal tubes are still used in oil paints or pharmaceutical gel products and supplements to protect against the introduction of gases which cause oxidation, consumers tend to prefer toothpaste tubes which do not dent, creased or deformed resulting in a gradual replacement with plastic or laminated. (INCPEN, 2011)

2.2.2 Plastic Tubes

The discovery of plastics changed the way products were packed and enabled toothpaste manufacturers to modify and reduce their packaging as well. A typical example was the plastic tube, which can now stand upright, has a greater cap, and yet is extremely widespread in products other than toothpaste, such as hand creams or shampoos. The success of the plastic tubes relies on the fact that it is more puncture resistant than the metal and the flattened end of the tube less sharp, thus avoiding the damage caused to the packaging. Furthermore the outer box can be avoided, as it can stand on the shelf without support which is another reason why manufacturers have begun to prefer plastic to pack toothpaste. (Stypka et al., 2005)
Many people show greater preference for plastic packaging, as for reasons of economy they often want to exhaust the entire content of the package before they discard it. A Plastic tube definitely facilitates the dentifrice removal process, relative to the metallic one, as they can be subjected to compression without the risk of perforation and tearing. The downside to this process is that the end does not stays coiled and as a result after squeezing, the product is removed from the orifice and reaches again the end. However for some people the tendency of the plastic to unfold and straighten serves more in the migration of the dentifrice as is not necessary to exert great pressure at the edge of the tube but a small pressure is sufficient in the middle or at the top. (Miller, 1995)

2.2.3 Laminate Tubes

One of the many attempts to develop the packaging industry, was based on problems mentioned above. Accordingly, a new innovative material created, the aluminum/plastic laminate, which offers higher reliability and is used in a wide range of consumer goods such as food, beverages, pet food but mainly for toothpaste and cosmetics.

There is a large variety of laminated packaging formats. Usually their multilayer structure is composed of a thin aluminum foil, the thickness of which typically ranges between 6-30μm (microns) and is sandwiched, or laminated, in a matrix of paper and/or plastic layers. The most common plastic is polyethylene terephthalate (PET), which is usually combined with low density polyethylene (LDPE). (Slater et al., 2011)

The following schematic diagram, in Figure 5, illustrates an example of a standard toothpaste tube packaging.

Figure 5: Different layers of a typical laminate tube. (Source: Slater et al., 2011)
According to INCPEN, 2011, there are cases where instead of aluminum foil, a barrier layer of ethylene vinyl alcohol (EVOH) is being used. The cap on the toothpaste tubes is made of polypropylene (PP) and weighs 2-5 gr, and typically 100 ml of toothpaste are contained in a tube of 7 gr.

From the user’s point of view, laminate tubes are superior compared to aluminum tubes and are clearly more functional. (Elliott, 2010) The advantages are based on the protective properties of the aluminum foil as it serves three main functions. Initially it provides mechanical rigidity to the packaging. Secondly, if there was not the aluminum sheet, the perfumes of the content would have penetrated the layers of the polymer and would have been lost. Last but not least, is the fact that it offers long-lasting protection from ultraviolet light (UV) and gas diffusion inside the packaging. The UV light can be destructive for nutrients, especially fat-containing foods like milk or cream and other products as it causes photo oxidation reactions. (Slater et al., 2011)

The above reasons resulted in the adoption of the tubes, according to Evelyn Tweedlie, vice president in Europe at Essel Propack, who points out that “Aluminium tubes dent, crease and even split when squeezed at least twice a day during their use by the consumer”, while she adds that this is also likely to happen to laminate tubes without the product coming into contact with the external environment. An impermeable layer in combination with the cardboard box for extra protection during transport and storage is inevitable as one of the key requirements in the packaging of toothpaste is to protect against the loss of flavor and as Tweedlie notes, “Peppermint oils are very aggressive”. (Elliott, 2010)

Apart from functional benefits, laminate’s superior printing quality, gives aesthetically more value to the product. To form the aluminum tube, a slug of metal is used, which is firstly extruded in a tube and then offset printed. The high printing quality is facilitated by the construction method of the laminate tubes, as the sheet material allows letterpress or rotogravure printing techniques. Then the printed sheet is slit and gently takes the form of a cylinder with the use of forming rolls. This is sealed using high-frequency heating and is cut lengthwise in a cutting station. (Elliott, 2010)
A disadvantage of this procedure, is that in contrast to aluminum tubes which consist entirely of an extruded piece, the “head” and “neck” of the laminate tube should be separately manufactured beforehand and then are bonded together. Conventional practice is to form the “head” and the “neck” on a mandrel, which in turn are fused to the top of the tube by high frequency heating. In other instances injection or compression molding is used to fuse the head to the body. (Elliott, 2010)

The fact that the head and neck segment does not have the same sealing properties as the body of the laminate tube, has negative consequences in toothpaste packaging. This problem tried to compensate Essel Propack by developing a seven layer barrier film that can be inserted into the compression molded tube shoulder. Another solution is fitting the inside of tube shoulders with doughnut or cup shaped inserts. (Elliott, 2010)

Although the low weight of the sheets, could be considered to reduce the environmental burden of the packaging, as it improves the ratio of product to weight, while reducing transport costs and mitigates the landfill taxes due to lower weight of the material which is discarded after use. However, the problems associated with the recycling of the materials used to manufacture the laminate packaging, invalidate the benefits they offer, particularly on the consumer side, who cannot find any environmental satisfactory method of disposal. (Slater et al., 2011)

The main reason why local authorities rarely collect tubes for recycling, is due to the structure of mixed materials and as with other light packages, the logistics needed for the collection and storage of sufficient quantity of tubes to justify the expenditure of energy required to be recycled, is a major challenge. To recover a ton of material, the collection of 150,000 tubes is required. Only in a few areas local authorities make use of waste facilities in order to recover this energy. (INCPEN, 2011)

2.2.4 Stand-up Tubes

Despite all the efforts to solve the problems caused by the material, the stability of the tube is not an easy task. While most tubes are designed to be stored lying, some attempts have been
made to stand on the cap. They are usually plastic laminates with an EVOH barrier and are able to stand up throughout their lifetime. On the other hand, the aluminum barrier consist of a “dead fold” which creates a flattened shape and as a result when the tube is empty they cannot stand. (INCPEN, 2011)

However some children's brands including Colgate’s junior range, are using standing tubes because their small size allows it. These brands that are targeted at adults have higher tubes, so the carton box is inevitable. An exception is the Corsodyl Daily, which is sold without a box.

According to Evelyn Tweedlie “It’s more user-friendly to stand them up on the cap in the bathroom”. Furthermore she adds that “Dispensing or flip-top caps are also used for ease of opening and dispensing.”

A typical case study is the packaging of GSK’s Sensodyne Pronamel, as shown below, which has a boldly oversized, pearlescent, flared cap that is combined with a cardboard featuring a cutaway section to highlight and promote the design.

![Figure 6: GSK’s Sensodyne Pronamel Stand-up Tube (Source: www.pronamel.us)](image)

As noted by the GSK’s design office Slice Design, “By looking at how consumers use toothpaste tubes, we created a new user-friendly structural design format for the launch of Sensodyne Pronamel. Standing on its head and introducing an easy-clean nozzle meant we could wave goodbye to bathroom mess.” (Elliott, 2010)
2.2.5 Pumps

An alternative proposal of packaging, for better storage of the toothpaste, are pumps which reduce the mess in the bathroom and offer easy dispensing which requires no compression, and deliver a measured amount of toothpaste and reduce wastage. However, their market share is small and their demand is limited, as they are much more expensive than other forms of packaging.

![Commercial Toothpaste Pumps](https://perimeterbp.wordpress.com)

Figure 7: Commercial Toothpaste Pumps (Source: https://perimeterbp.wordpress.com)

As shown in the figure above, pumps and shaving cream style dispensers, are available in a variety of styles, such as nozzles, removable caps or push buttons. They are usually fabricated through injection molding from polypropylene components. They have a thick wall section, which functions as a barrier to protect the content from drying out and loss of flavor. Their weight is relatively large, as 100ml weigh around 33gr. However, the cardboard protection is not essential during distribution and storage on shelves. (INCPEN, 2011)
Finally, an innovative packaging proposal that is worth mentioning, comes from the design agency ABC, which is based in Athens, for the series of Greek origin toothpaste products named Frezyderm. This package, (see Figure 8), which has been awarded by innovation packaging awards 2016, could belong to the category of pumps, although operating with plunger. According to ABC designers “Our aim in this project was to design a unique packaging for a series of innovative products. Also, the tube is specially designed to protect the content efficiently and with a simple mechanism it allows the consumer to use all of the content.” (Lin, 2016)
2.3 Protection Requirements

The large market competition have significantly contributed to the development of the packaging of toothpaste, but we should not forget that its main role is primarily to offer protection to content and its active ingredients, but also to provide convenience in the way the users consume and dispense it.

Once the toothpaste market is world-wide, it is necessary to survive in all climates of the world and to be protected against all potential risks and conditions such as extreme temperatures, humidity, impacts, vibrations and compressions throughout the product life cycle, from manufacturing, distribution and sale to the environment of consumer use. A toothpaste is likely to fall on the floor, to strain during transport on a journey or to be used in the shower. Nevertheless it is necessary to maintain the safety and hygiene throughout the continuous use. It is equally important to consider the cultural habits around the world as the way the toothpaste is dispensed varies. There are people who use their finger to “brush” their teeth, while for children this process is a challenge. Thus, the packaging must be able to handle all methods of administration and to ensure that the user will be able to exploit all of its content.

Another fact that must be considered in the design process of toothpaste packaging, is the different forms in which it is marketed, like gel, powder or paste. In developing markets, tin cans are often used for powder, sachets for paste and gels are often sold in pumps, while in these countries, consumer purchasing needs are met. (INCPEN, 2011)

Occasionally has occupied the question of whether personal care products and in particular toothpaste, are considered cosmetics or drugs. According to Food and Drug Administration (FDA) agency, whether a product is a cosmetic or a drug, under the law is determined by the products intended use. Toothpaste for example, if it has ingredients for anti-cavity or anticaries protection, is registered as a drug while in any other case is considered cosmetic. For that reason, toothpaste companies, have a legal responsibility for the safety of their products and ingredients and since they are considered nonprescription drugs, they must receive premarket approval by FDA and conform to special regulations, called “monographs”, for their category.
These safety regulations, can influence the toothpaste packaging as well. There is a requirement which keeps dentifrice tubes in a relatively small size, which is the toxicity of fluoride, an active ingredient that is contained in all toothpastes, because of its proven cavity fighting action. According to the final monograph, all dentifrice products, such as toothpaste and toothpowder have a package size limitation, and they must not contain more than 276 ml of total fluorine per package. The only exception applies to anticaries drug products marketed for professional office use only. In this case, there are no restrictions on the size of the package as long as they have a label indicating “For professional use only” and “This product is not intended for home or unsupervised consumer use”. Lastly the final monograph requires the anticaries products, to state all disclosures in a prominent position on the label, to ensure public safety. (Sandier, 1997)

Another requirement that concerns the FDA is that the container must protect the product from contamination by exogenous liquids, solids, loss of efflorescence, deliquescence or evaporation, under ordinary conditions of handling, shipment, storage and distribution. For that reason, it is highly essential that all fluoride, powdered toothpastes, to be packed into tight containers, to avoid exposure to water, moisture or UV light. (Sandier, 1997)

Furthermore, although dentifrice products, along with all dermatological products and insulin, must be capable of being closed tightly, they are the only over the counter (OTC) drugs that are not subjected to FDA’s tamper resistant regulations. (Sandier, 1997)

2.4 Statement of the design problem

So far, a comprehensive comparative analysis between all types of toothpaste marketed packages has been presented and we can already assume the need for redesigning the toothpaste device. However at this point it is necessary to further analyze the functional and sustainable problems that will lead to the definition of design requirements presented in Chapter 4.
2.4.1 Environmental Approach – The recycling problem

As simple toothpaste tubes become more complex, the more they harm the environment. Old style aluminum tubes, made from a single slug of metal, were much more recyclable than laminated ones, who replaced them. (Elliott, 2010)

On the other hand, the extraction of bauxite, from which aluminum is made, is also detrimental to the environment, as the melting process is much more energy intensive. In addition, tubes that are still made of aluminum, may carry a label stating that they are recyclable, but in fact a disposable tube of toothpaste, which has product residues, a plastic cap and a thread, is not welcomed in an aluminum can. (Stypka et al., 2005)

Switching from the use of aluminum to the use of plastic for the tubes, it could be a positive action in environmental terms, but dentifrice residues can give rise to the same problem. A plastic tube, may contain high contamination to be introduced into a recycling system, while it takes about 4000 empty plastic tubes to convert into a ton of plastic. (Stypka et al., 2005)

As mentioned in chapter 2.2.3, the benefits of laminates, from performance aspect are numerous and therefore its use is growing rapidly. In contrast to these advantages, laminated packaging systems have a serious drawback. The combination of plastic and aluminum in the waste, presents a technical challenge to recycle them, so these materials are discarded by conventional means. (Slater et al., 2011)

“Typically the laminate is polyethylene (PE) and aluminum foil bonded together with an adhesive and so difficult to separate,” says David Boorman, business development manager of specialist laminate recycling company Enval. “For recycling purposes these laminates are not strictly aluminum, nor are they pure PE, so instead they typically go to landfill or incineration.” (Elliott, 2010)

Environmentally this is undesirable, since aluminum and plastic resources used for production, are wasted and should be extracted from the nature, in order to renew them. This has consequences on economic level too, as this method is very costly and the significant value of
both the aluminum and the plastic could be exploited, if there was a sustainable way to recycle. (Slater et al., 2011)

Despite their lightweight nature and the relatively low price, so far they are strictly non-recyclable, since the collection and recovery of recyclates is driven by weight-based targets. It could be applied, if replaced by heavier packaging options, but again their viability is controversial. (Slater et al., 2011)

As mentioned by Boorman, “We see much more environmental benefit and financial value in recovering the aluminium. It does not lose its value and can be recycled infinitely. And then there’s the replaced energy consumption to create it in the first place.” (Elliott, 2010)

Despite the difficulties, it has conducted much research to find a solution to the problem of recycling of laminate packaging, but there is currently no sufficient and proven technology, capable of separating the plastic from aluminum, and to fully recycle these materials in an efficient and cost effective manner. (Slater et al., 2011)

The only sophisticated plastic / aluminum laminate recycling operation created by Enval Company, which was formed after research at Cambridge University’s Chemical Engineering Department, where they managed to separate the aluminum from laminate by heating it in low oxygen environment to evaporate the plastic. After 12 months of operation of a pilot project conducted at Cambridge, the company has now opened a large-scale plant in Luton. Although Enval collaborates with major toothpaste brand owners to develop a recycling certification system, this expertise is not yet widespread around the world. (Elliott, 2010)

More specifically, the Enval Process is based on a technology known as Microwave Induced Pyrolysis, in which the energy required for heating the material is provided by microwaves. During pyrolysis, organic materials such as paper or plastic, are heated in the absence of oxygen, thereby causing degradation of the material through the effective reduction of the molecular weight, but without taking place any oxidation, combustion or incineration. Carbon, which is a highly efficient microwave absorber provides heat exchange, and transfers this energy to the plastic, by induction, for the pyrolysis. In the case of laminates, thus generated
degradation of the plastic which is converted into other useful products such as pyrolysis oils, which can be used either as fuel for electricity generation or as feedstock for specialty chemicals. The fragile aluminum foil remains intact, and is exported as a pure material, suitable to be reintegrated in the aluminum recycling supply chain. (Slater et al., 2011)

Another issue that burdens the environment, and should be reviewed if its use is necessary, is the cardboard outer box. Cartons and tubes cooperate as a system for the protection of the product during distribution and provide stability to the retail shelf, while their use ends there. Typically they weigh 14.5 gr for a tube of 100 ml. Whilst through the years, it has been observed that the energy and the material used for the tube, has been reduced significantly with the aid of the carton box, as wastage would be greater if destroyed. (INCPEN, 2011) This of course, could change if there was attempts to redesign the packaging of toothpaste.

In dental care products containing medicinal application, an instruction leaflet may be necessary, so it still remains essential a packing box. Nevertheless, the tendency for packages such as plastic stand-up tubes, which do not require an external box, is constantly concerning toothpaste brands. (Stypka et al., 2005)

Trials with cartonless tubes, generally have failed to win consumer acceptance, apart from lower tubes for children. (INCPEN, 2011)

According to Bob Houghton, marketing manager at Chesapeake, the consumer seems unwilling to depart from standards that is accustomed for years. As he characteristically reports, “Tubes were dented and damaged and it was awkward to retail. There was also an issue with tamper evidence.” (Elliott, 2010)

Another view prevails, which claims that we should extend the end-use of products manufactured after the collection and processing of recycled materials. Of course, a toothpaste carton may consist at 80% of recycled paper, but this does not imply that it is good to use packages that are no longer necessary. For that reason, it is important to take seriously into account contagion effects that lead to certain changes made in the name of improving the environment. (Stypka et al., 2005)
Finally, toothpaste residues caused by each type of tube where the toothpaste is packed, definitely worth mentioning, since they not only hinder the recycling process, but also have an overall negative impact on both users and the environment.

Unintended product residues (UPR), is defined as “waste which the consumer does not make a conscious decision to generate or dispose of”. According to a research carried out by WRAP Company in collaboration with INCPEN, which studied products that the consumer cannot withdraw from the container, amongst which toothpaste products too, which are difficult to extract from the tube, as well as products made useless even before the consumer has the opportunity to use them.

According to this study, the negative environmental impacts related to UPR are the following:

- The waste of raw materials used for the acquisition, processing, transport and packaging of a product which is not fully consumed.
- The effect of the waste product, which is discarded along with the containers and the negative impact on recycling material destined for reprocessed packages.
- The negative reaction of consumers, who pay for a product that are unable to use completely.

Any additional cost encountered by manufactures, who must overfill the packages, after their obligation to follow Weight & Measures Quantity Declaration Labeling regulations imposed by international markets, since the quantity indicated should be equal to the amount that can be extracted from the container. (Patterson et al., 2014)

Figure 9: A commercially available, a 3D printed and a DIY toothpaste squeezer.

(Sources: ebay, thingiverse, pinterest)
The inconvenience of users, from UPR can be confirmed, if we take a look at all the artifacts that have been developed over time to assist the toothpaste extraction process. As shown in the images above, it is about devices that can squeeze the toothpaste and they may be commercially available, either can be 3D printed or they are DIY constructions.

According to results of this research, the toothpaste category has a wide range of UPR levels. Although closures varied the openings were similar, so the range is attributable either to the material of the tube, or on individual behavior of the consumer. In order to reduce residue levels, manufacturers could consider the effect of various materials and also to provide consumers with instructions on how to utilize the whole product. (Patterson et al., 2014)

In this report, they have issued some guidelines, according to which the UPR levels could be reduced by:

- the design of a packaging that facilitates emptying.
- proper reclosability so that the product remains fresh for as long as possible.
- providing a “window” or a transparent aperture so that the UPR be visually apparent to the consumer.
- better designed openings and closings.
- an inner packaging, or a coating which adheres to content as little as possible, and will help consumers to empty more product.
- informing consumers on how much product they throw, and provide information about what is the best way to empty with safety, different types of packaging.
- osmosis levels.
- on-pack labeling with tips on how to use the product until its last drop.
- dosing concentrate products.
- wide range of sizes, depending on the purchasing needs.
- portion size.
- delivering products in accordance with the abilities of the users.

(Patterson et al., 2014)
2.4.2 Human Centered Approach – Functional Problems

So far, it is clear that the traditional toothpaste tubes, although they have been evolved over time by their construction materials, have turned the problem of recycling a very difficult task. It is also a fact that up to now they do not offer any solution that is user friendly. The packaging is intimately linked to the product as it is the only mean by which a user interacts with, in order to dispense the toothpaste. Thus it is particularly important to study the packaging of oral care products from the users’ point of view. The methodology that has been followed in order to identify all the problems associated with the manner of use of dentifrices includes, the testing of different existing products during the personal daily experience in order to compile a bugs list, the pain storming technique in order to identify all the inconveniences, observations of the operating environment of different users and analysis of the tooth brushing process, and finally brief interviews with users.

Below are concentrated some negative elements and product vulnerabilities that represent potential problems which have arisen from the findings above combined with the results obtained from the market research in Chapter 2.2.

- Traditional toothpaste tubes do not provide users with the appropriate quantity of toothpaste on their toothbrush. Thus the amount of toothpaste cannot be determined nor controlled.
- The force required to extrude the product from its package, frequently causes waste and mess of the tube.
- In case a larger quantity of product than the required is extracted, it is impossible to reposition it back into the container.
- The fact that the dosing of the product is uncontrollable, results in the high concentration of residual toothpaste in the tube orifice, so when it dries it is not feasible to close the package and makes difficult the dispensing process.
- The inevitable coiling and denting of the tubes, make them not aesthetically pleasant.
- Stability issues since most of the traditional toothpaste tubes are not able to stand in space.
✓ The necessary positioning of the tube in the container where toothbrushes are stored, can be devastating for the product, as moisture and stagnant water creates fertile ground for the growth of microorganisms and mould.

✓ The lid which is often removable, disappears resulting the incoming air from the orifice of the packaging to dry the product.

✓ During transportation on a trip, it is possible to be accidentally compressed, with the risk of spilling or tearing the packaging, and smear nearby objects.

✓ It is impracticable to use the full content of the toothpaste.

✓ The amount of product remaining in the container is not visible.
3. Packaging Design Methodology

In this chapter the literature that derives mainly from the marketing arena field has been utilized, in order to understand the role and importance of packaging and consumer behavior, while presenting the main models that have been developed for the packaging development process, and the individual components.

3.1 Packaging Design Definition and Functions

To assess the value of packaging design, and recognize its position in the global economy, a reference to the definition and the functions of packaging design, is very important. In contemporary literature, the definition of packaging design, is encountered in several ways approaching it from various angles. The most fundamental definition comes from Paine, according to whom “Packaging is a coordinated system of preparing goods for transport, distribution, storage, retailing and end-use and a means of ensuring safe delivery to the ultimate consumer in sound condition at minimum cost”.

Based on the core functions of packaging, Paine continues his description by referring to it as a product whose primary purpose is to contain, protect, preserve, inform, sell and provide convenience. For that reason can be regarded as an extension of the actual product, and through the new possibilities that adds to it, enhances its performance throughout its life cycle, from manufacturing and assembly to use and recycling. On the other hand, the value, even the need for these added features, is considered controversial and there are various opinions on whether the packaging is a waste of materials, even at what extent these functions may be considered necessary. (Paine et al., 1992)

3.2 The Role of Packaging

The concept of packaging first introduced in the 19th century when the new technologies of the era started allowing manufacturers and producers to distribute their products in pre-packaged forms as they were able for the first time to pack and to transport them to the market, in an
attractive way. In these early years, the role of the packaging was essentially utilitarian, and although most products have become complicated, these two functions continue to determine the form and function of the packaging since the key requirement is the protection during distribution so as to be transferred intact to the shelves. (Calver, 2004)

Certainly, in the contemporary market, as society has reached another level which looks beyond the functional aspects of the package, a greater emphasis is given on how it feels, seems and speaks. The packages are imposed to follow the change in consumers’ lifestyle. (DuPuis et al., 2011) For example, people spend most of the day away from home and the package should support this mobile lifestyle, thus lead to the development of travel sized products designed to fit into bags briefcases and other luggage. (Calver, 2004) This has led packaging to improve, expand and enhance their functionality, as they are now made of high tech materials with unconventional forms and shapes and innovative features, like pull tops, self-cooling systems, biodegradable inks and date codes that change color when expired, providing a competitive advantage. (DuPuis et al., 2011) The changing role of packaging is perceived even by the evolution in the term package, as from package (container) is now translated as packaging (a container that has written communication about its specific content). Hence is now considered a marketing tool, which through the package offers a complete retail experience that allows consumers to be charmed and have fun. (DuPuis et al., 2011)

The position has rightly won the packaging in the marketing mix, has led to the disappearance of the provision merchant who has been replaced by the shelf service retailer. It is no longer a passive functional device, but an active sales tool, which makes its presence noticeable in the crowd, sales the product at the point of purchase and promotes the brand values and personality. It functions as brand manifestation. (Calver, 2004)

Furthermore, packaging has always played a significant role in the differentiation of similar products. Originally graphics may have had predominant role at diversifying one product from another, now this role has been taken by the structural design. This is accomplished either by the shape, for example a bottle of Coca Cola, or by the color, the surface finish and materials. The feature “green” of Perrier bottles, now belongs to this brand. In other sectors, such as
cosmetics and perfumes, the sense of touch can communicate the aspirations of a particular lifestyle on a subconscious level. More data on characteristics to be considered when designing a package will be discussed in detail in a following subsection. (Calver, 2004)

Briefly the six main objectives that should be met when designing a packaging are given below: (DuPuis et al., 2011)

1. **Containment** - The manner in which the packaging holds the product depends on each type. Liquids, chemicals, dense solids, perishable foods, pharmaceuticals, small or oversized object, and high tech or high cost goods, all have unique needs and varying demands on the containers that secure them.

2. **Security** - Some products require special temper evidence, while others need sanitary and freshness measures. In these cases, they must provide special guarantees for both the consumer and for the manufacturer. From oxygen barriers to holographic security seals.

3. **Protection** - If a product is tampered or damaged, there is nothing more than pure material and financial waste. For that reason, it is very important packages to address the needs for strength and protection, in particular to consider the ease in which the product can be damaged during transport and handling and whether they can withstand environmental factors.

4. **Convenience** - Elements such as portability, display, opening, closing, usability or reusability, determine its position in the market. For many categories of goods, the issue of consumer convenience is paramount. A smart package acquires marketing advantage, when taking into account the needs of end users provide unexpected solutions.

5. **Information** - The packaging bears the enormous responsibility of informing the consumers in order to provide all the required knowledge about what is a product, how to use it and when, how not to use it and why not.

6. **Marketing** - By speaking the right visual language on-pack, which connects intellectually and emotionally the consumer with the product, it is vital in order to observe it, to desire it, to buy it, and to remember it. This will elevate the intention of purchase.
3.3 Types of Packaging

Usually a package from conception of the idea to implementation, ranges from a simple wrap to a special purpose container. In literature packaging types are standardized and their structure can be categorized in a hierarchy of three levels, consisting of primary, secondary and tertiary packaging. (Bramklev, 2007)

A typical example is the six pack of bottles (primary) with a simple handled collapsible package (secondary) and the insulated box that keeps the product cool and fresh while in transport (tertiary). All these three levels of packaging, contribute to something equally important in the delivery process of the product from manufacturer to consumer. (Capsule, 2008) To determine the optimal design of a packaging system, a cost-benefit-trade-off analysis of the three levels of packaging is required, which are presented in detail below (see Fig. 10).

- **Tertiary Packages** – They are also known as transport packaging and the purpose of their existence is to offer protection, during transportation and navigation among all stakeholders in a channel. As expected, the design result is a box, pallet, roll cage, stretch-wrap, with little to no brand messaging, since the consumer rarely comes into contact with the tertiary sector. The dominant role is mainly determined by the need to improve the efficiency formed during construction, packing, palletizing, shipping, storing and unpacking. Today in tertiary packaging, there is more emphasis on the functioning,
while there are prospects in the future to study the development of new ways of standing on a pallet.

- **Secondary Packaging** – or transit package, is the connecting link between function driven tertiary and brand driven primary package. In the design process of the secondary packaging is important be given just as much attention as the primary, since it serves the role of displaying the product on shelf via trays, display packs and shipping packers. Other parameters to be considered are the characteristics of the brand personality to be transmitted, the way they are stacked, the way in which contains the product, as it provides access to consumers and the way in which merchants would dispose it. In order a secondary package to be successful, has to balance the function with the form, and complement the personality of the brand relied on the primary packaging.

- **Primary Packaging** - As it is more than any other type of package closer to the consumer, always gets all the credit and attention. It is always in plain view, either on the table or in the consumer's cupboard, and therefore most brands invest all their attention through science and research, on what should a primary packaging achieve. In consumer-product relationship, the primary packaging has the reins, and should be designed to reflect this leadership position, in a way to equilibrated form and function, in any context. Usually, it is the only face of the brand, and the image acquired by the consumer derives from it. This leads either to build a loyal consumer a stronger relationship or to seek knowledge of the brand, which may work adversely. A primary packaging, for example, could be designed with any consideration of sustainability, but it is proved that the brand does not follow sustainable practices in the tertiary sector. For that reason, a greater responsibility may be given to primary packaging but it should not take all resources and attention away from other elements of the brand.

According to Hanlon, Kelsey & Forcinio, 1998, for marketing reasons, packaging can also be classified in four package categories, either by the package’s intended destination, or by the type of the customer. These types require different technologies and talents for their accomplishment, and are listed below.
✓ **Consumer Packages** - which are related to small items that are produced in large numbers and are decorated in order to maintain their self-selling function. They utilize virtually, small volume containers of all kinds of form and shape materials and their size is intended for individuals and small family groups. The range of these products extends from food and non-prescription drugs, to personal hygiene and recreational needs.

✓ **Institutional Packages** - these are larger quantities of products whose design is simpler and the packaging includes film wraps, large bottles, jugs, pails, drum, as well as moderated sized corrugated boxes and industrial bags. Commonly they involve a range of products such as office supplies cleaning products, food and beverages.

✓ **Industrial Packages** – they are mainly focused on optimizing logistical aspects, and they usually hold several thousand pounds of product. They consist of heavy wooden crates, big bags, conventional corrugated boxes, large drums and glass carboys. There are also moulded plastic tanks with build-in legs and heavy-film lined corrugated or wooden pallet structures for liquids such as aseptically packaged food ingredients. Historically their declaration is limited to identification and instructions but competition has contributed to labeling ideas borrowed from the retail sector.

✓ **Military packaging** - this is a type of protective packaging, highly specialized in which features like product identification and inspection processes are defined by the government and documented in intricate detail. The levels of protection are many, but economics have caused many military goods and items purchased for the federal government to be downgraded to consumer - weight packaging.

It is important to note that these categories mentioned previously, the institutional and military packages, may contain industrial goods, while consumer packages, consumer goods. This may be the case with packaging in general since is very often regarded as an extension of the product itself. (Hanlon et al., 1998)
3.4 Packaging Design Trends

It has been observed throughout the evolution of packaging history that trends always reflected the attitudes, values, desires and dreams of the purchasing public, thus affecting and shaping the society and establishing human progress. The multi-dimensional world in which we live, aided by the Internet, has contributed to the rapid spreading of large amounts of information around the world, leading fashions and trends often to overlap and conflict. In order to enable people to filter the information derived from the mass market, and identify a potential developing trend with mass appeal, is usually divided into subcultures. (DuPuis et al., 2011)

To understand someone how trends work, it is important to observe their life cycle. A trend has ups and downs and once conquers the massive acceptance of the world, either reaches its peak and becomes mainstream, stabilizing the public interest and gradually decreases, or simply dies without even start to grow. In the terminology of marketing, the process by which a new trend begins to be accepted in the market, is called diffusion. There are several theories about the mechanics of diffusion, with the most widely accepted to be the Diffusion of Innovation Theory of Everett Rogers. (DuPuis et al., 2011)

In the case of packaging design, as its role is to sell products and is closely related to the needs and preferences of consumers, trends are often translated into functional applications. Since trends alternate rapidly and there is always the risk of bad timing with the target consumer, a visual concept that expresses a trend, should be applied with careful consideration of the brand and its promises, in order to match with it and attract the right buyer. Certainly the growth rate of a packaging trend is slow as it takes a long time to make changes. Typically start up brands are those who adopt more easily a trend, since their risk is smaller. Major brands take a longer time, but when they adopt a trend, is the time that reaches its peak. To keep up a trend with the different stages of acceptance, it is vital to analyze the purchasing habits of a particular public and consequently to forecast the limits that a brand can reach. (DuPuis et al., 2011)

From the perspective of the designer, it is equally important to understand what it is that motivates and defines a visual trend. Predominantly these concepts are influenced by the
environment, the social attitudes and beliefs. The identification and evaluation of trends in packaging is determined by a combination of elements such as color, typography, imagery, structure, form and materials, which can be used to express a trend. (DuPuis et al., 2011)

As shown in the following diagram, which illustrates the packaging trend cycle, trends are influenced by a larger set of strategic themes, developed through a variety of consumer, business and media trends. Understanding trends in turn helps designers to entertain, affect, inform and motivate consumers in their purchasing decisions. (DuPuis et al., 2011)

**THE PACKAGING TREND CYCLE**

![Diagram showing the Packaging Trend Cycle](image)

Figure 11: The Packaging Trend Cycle (Source: DuPuis et al., 2011)
3.5 Consumer Behavior Analysis

Changes in consumption patterns and habits, which are mainly due to the increasing internationalization and globalization of business, the change of lifestyle, the smaller households, and the continuous consumer search for comfort and convenience has established new demands and a very high competitive environment. (Rundh, 2005)

The outcome is that the consumer now has countless choices between similar products, which are trying to gain his attention. (Ahmed et al., 2014) In an average supermarket, a typical shopper passes by approximately 300 items per minute. The package is therefore the one which has the role of the seller in order to create an overall positive impression. (Rundh, 2005) The advertising may trigger awareness and desire for a product, but the packaging serves as the only tangible element of communication, before the final decision that stimulates purchasing behavior, and differentiates a brand. (Ahmed et al., 2014) Without it there is no possibility of distinguishing them from the rest. (DuPuis et al., 2011)

It all started the late 50s, with the emergence of supermarkets, which created an explosion of new products. Thus the science of branding began to grow rapidly, by studying and analyzing demographic and psychographic characteristics of consumer purchasing behavior, like brand loyalties, which led to the development of new ideas from marketers and designers. Brand personality and brand essence, were terminologies used to explain new methodologies and principles which were adopted to make packaging more sophisticated and the perfect image display medium of brand positioning and differentiation in the market. In the mid 90's, the value and power of marketing strategies were now clearly effective, as some products became so synonymous with the name of their brand, which were used to describe an entire class of competitors. (DuPuis et al., 2011)

To achieve differentiation, positioning and become a distinct personality, strong emphasis were given on characteristics such as unique typography, colour and graphic elements to enhance the character of the brand and the human connection with it. Thus the secret to a successful marketing is undoubtedly the deep understanding of how consumers experience a
brand. On the one hand consumers are often associated with brands on an emotional level. A package may have no voice, but is designed to activate the senses and this connection requires something more than a pleasant aesthetics. We should not forget that a product is a result of a logical selection that must satisfy both the rational and objective demands of consumers.

To understand the behavior of the consumer, has a great interest the reference to the consumer's decision-making steps, the study of which could provide new design opportunities that will boost him to buy a product. Often, the target audience of a particular product, can change at any moment, but this process remains stable.

According to DuPuis, the five stages that describe the behavior of the consumer are the following:

1. **Recognition of the problem** - Once consumers become aware of a need, which is often triggered through the marketing and advertising messages, the idea of making a purchase begins.

2. **Information Search** - The consumer seeks a value and examines the options for covering a need. Elements which may affect, are the past experience, the affinity of the brand, references from friends and the authorities, and sales people.

3. **Evaluation of Alternatives** - The consumer analyzes the information gathered to assess the value based on personal criteria such as emotional and rational factors.

4. **Purchase Decision** - The consumer decides to buy the product based on the perceived value. He chooses the place to buy, based on price, availability, terms of sale, retail location or past experience. He must also choose the moment of purchase. Alternatively simply chooses not to buy.

5. **Post-purchase behavior** - The consumer finds the desired value during the consumption or use, or the product does not meet the original need.

Therefore, it can be concluded that the role of packing is particularly strong and can easily affect the purchasing consumer's decision. According to concept of Gestalt, a package is often perceived as part of the product and it is very difficult for the consumer to separate the two. According to surveys, most consumers are happy with the quality of the product
after purchasing the desired package. In fact, a good packaging and a good product quality may not coincide but a well-designed packaging always refers to good quality. (Ahmed et al., 2014)

There are many factors that have contributed to the consumer's decision. Increasing customer value and lowering cost are certainly two of them. (Rundh, 2005) Even if a brand wishes to assert a higher price, the packaging must convince the buyer that it worth the extra cost, to gain his trust and to maintain it so that he continues to use it. (DuPuis et al., 2011) Aspects such as packaging colour, typography, illustration and graphics are essential on how a product is perceived, but cultural differences should be taken into consideration, when a product is promoted in different parts of the world. (Ahmed et al., 2014)

The opportunity to design an innovative packaging can also bring large benefits to consumers and producers and may actually add extra value to the product if it meets a consumer need such as portion control, recyclability, tamper proofing, child proofing, easy open, easy store, easy carry and non-breakability. (Ahmed et al., 2014)

Another important factor is the “Green Image” of the packaged products and since people are becoming more concerned towards green purchasing due to the green consciousness for environmental protection, it should be taken seriously into consideration. (Ahmed et al., 2014)

Finally, promotional approaches as cash discount, in-store display as well as window display strategies have an important role to encourage customers to buying in a more impulse manner. (Ahmed et al., 2014)

### 3.6 Research on Packaging Design Process

Until now, it has been repeatedly highlighted, the role of packaging design. For many consumer goods packaging is as important as the product itself, which without packaging is not feasible to exist. In this case we can assume that a Product Development Process has been completed with the development of the packaging.
This chapter is a brief reference to the most widespread models (Product and Packaging Development Processes) and an attempt to study the interdependence of these processes. Is also made a study, around the eco-design strategies and tools for assessing the effects, all of which can contribute to improve the packaging and to reduce environmental impact. This research has the ultimate aim to be exploited during the development of the design proposal that will follow in the next chapter.

Looking back to the current bibliography on the design methodology, there is an extensive range of approaches about the development and design of products. It is a fact that most of these approaches do not take into account the packaging in their models, leading to a very limited number of publications describing the overall design process of the packaging and most of them focus on specific product areas. In addition it is worth mentioning that another shortage occurs in the literature, which is the integration of environmental issues particularly in the initial design phase of these models. (Bucci et al., 2007)

However it has become a reference attempt in the widest range of information in order to cover these topics.

3.6.1 Product Development Process Models

One of the most common procedures for design, on which most models are based, is the Design Cycle, of Rozenburg and Eekels, which was presented in 1995, as shown in Figure 12. It consists of the Analysis phase where the designer is trying to understand the problem and to define the criteria to be satisfied, the Synthesis phase where the production of potential solutions begins which will satisfy these criteria, the Simulation phase, where these solutions are simulated and the properties expected from the design are explained and subsequently are assessed whether these objectives are achieved, on Evaluation phase, and finally the Decision phase whether to proceed or not, from which arises an acceptable design. (Wever, 2008)
This process is not linear but iterative and requires constant feedback. The authors consider this cycle as the most fundamental design model and such characteristically have declared that: “Someone who claims to have solved a design problem has gone through this cycle at least one” (Klooster, 2002)

Another approach, which provides a complete overview on product design methodology, in the industrial environment is the **Product Innovation Process** of Bjärnemo, which is shown in Figure 13. This process includes a series of activities that lead the admission to the market of a novel product in order to be prosperous. (Bramklev et al., 2005)
These activities may be research on an entry or applicable level, diagnosis of the market needs, selection of the marketing strategy, design and development, production and dispensation, sales and customer service. (Bramklev et al., 2005)

As shown in the diagram above, the product planning process is held before the real product development project is approved. Search and identification of new opportunities, mostly conducted during the market research and development of technology, which are given priority through the presentation of a product portfolio composed with miscellaneous proposals concerning the final product. At this point, a mission statement is significant, for all the proposed designs, which gathers the required information about the final development of the product. (Bramklev et al., 2005)

An extension of the models mentioned above, particularly popular among design engineers, is the **procedure model of Ulrich and Epinger**, which is described in terms of activities on an operational level. In their book they define product development as “a set of activities beginning with the perception of a market opportunity and ending in the production, sales and delivery of a product”. These three parallel processes, the designing, manufacturing and marketing process, interact during the whole process. The interaction or otherwise integration is concurrent and applied either vertically or horizontally between the individual processes. Particularly important is the fact that this process is characterized as a generic, which means that is independent of a particular product type and for that reason, is considered the most comprehensive as it can be adapted to any market pull situation. (Bramklev et al., 2005)

![The generic Product development process](image)

*Figure 14: The Generic Product Development Process (Source: Ulrich and Epinger, 2008)*
The generic product development process, is constituted of six steps and as shown in the picture above are the following:

- **Planning**: Starts before the product development process and the acceptance of the project. It includes business strategy, evaluation of technology and market ambitions. The results of this phase is the mission statement through which the target market, business objectives, basic assumptions and constraints are defined.

- **Concept Development**: Determine the needs of the target market, while different options and product concepts are produced and assessed. Essentially the concept gives details about the form, function and characteristics of the product which is often attended by the specifications, analysis of competing products and the economic report of the project.

- **System Level Design**: Includes product architecture, i.e. the mapping of the functional elements of the product to natural components, referred to as chunks for the disintegration of the product into subsystems and constituents in order to draft the final assembly. Results of this phase is the structure of the product geometry, the functional specifications of the subsystems and a flow chart of the entire assembly procedures.

- **Detail Design**: Involves the total description of the geometry features, material requirements, tolerances for each individual item of the product and all the standard parts to be supplied. At the end of this stage, a process plan is introduced and the required tools are designed.

- **Testing and Refinement**: Is implemented at the numerous preproduction adaptations of the product, where the alpha prototype is made to determine whether the product works or not as planned and if it reaches the desires of users. Then a beta prototype is constructed for testing the performance and trustworthiness, which identifies the necessary mechanical modifications in the end product.

- **Production Ramp-up**: The phase during which the product is manufactured using the planned production system. The aim is to educate the manpower to restrict any problems.
3.6.2 Packaging Development Process Models

Regarding the packaging development process, Paine was the first who summarized a generic model, separating it into six stages: concept, preliminary sorting, prototyping, package engineering, package evaluation and package quality. (Bramklev et al., 2005)

Later presented by DeMaria, 2000, a more intricate packaging development process, classifying into three main stages, (Bramklev et al., 2005) where each phase is separated into a set of sequential steps (see Fig. 15). In her book describes all the steps required to create, to test and introduce the package in the market. It is considered a good guide for engineers and product managers for a successful packaging development. (Klooster, 2002)

![Diagram of Packaging Development Process](Source: Bramklev, 2007)

More specifically the three phases are as follows (Bramklev et al., 2005):

1. **Planning Phase:** Includes business planning and goals, project team configuration, package concept establishment, and feasibility assessment. This phase ends with concept user testing, development of package prototypes, testing of package, consumer usage and evaluation.

2. **Provision Functionality Phase:** It includes tests on the final packaging and final approval of the design.

3. **Package Launch Phase:** It comprises starting the production process, monitoring of implementation and performance.
A more holistic and dynamic approach, which focuses on developing a packaging system proposed by Bramklev, 2009 and is about a model that facilitates the creation of integrated products and packaging in the worldwide trade. In the given context, the holistic perspective establishes this procedure as generic and assures the ability to support the development of novel and innovative packaging designs and packaging systems required in the production industry with the ultimate aim of strengthening competitiveness.

Figure 16: The Generic Packaging Development Process according to Bramklev (Source: Bramklev, 2009)

The steps in the composition of the process, as shown in the above scheme, are as follows:

1. **Package Planning:** As input data to start this phase are market information in order to identify market opportunities involving either new consumer needs or new technologies, materials and production methods, which are assessed by priority, depending on the corporate objectives and if accepted the schedule and the distribution of resources are defined. Once pre project programming is complete, the output of the process is the project mission statement.

2. **Package System Development:** The first activity of this phase is the analysis of the mission statement, together with manufacturing specifications of the packaging system and the creation of candidate concept, which are evaluated for the final decision. Afterwards the concepts are analyzed in individual solutions and subsystems and the
production method is selected, elements which determine the overall packaging system concept, which is the output of this phase.

3. **Package Concept Development**: The data of the previous phase are used as input for the establishment of the specification of the packaging. Candidate concept is evaluated in turn and the most promising is distinguished by the selection activity.

4. **Package Design**: In this phase a quick build approach is applied on the selected concept as well activities such as design, prototype, building and testing. Then follows the assessment and the decision on the result of each design iteration. As outflows are drawings and technical data necessary for the production of the packaging.

5. **Production Ramp up**: This phase begins with a comprehensive range of design information, while the production system and the tools to be used in the final production are adjusted. At this point begins the production and is evaluated. Result of this activity is the documentation of the production system.

6. **Package System Integration**: As entry the output from each of the separate projects is received, which is necessary to incorporate them in the final system, while the interface of these subsystems are tested and evaluated.

7. **Package System Production Ramp up**: In this final stage, the adaptation and development of the production system is performed. Once developed all the tools required, begins the final production and after the assessment, the documentation occurs. (Bramklev, 2009)

DuPuis, 2011, presented in his book, a packaging design process, which consists of five phases. This process serves as a model and can be modified to fit into any project. But there are also factors such as the general scope of the program, research needs and the information available at the beginning of the program and timing constraints which may affect the order and flow of steps.
The following diagram shows a simplified overview of the steps by which a package can be developed from concept to implementation.

![The Packaging Process Diagram]

Figure 17: The Packaging Process according to DuPuis (Source: DuPuis et al., 2011)

The phases are the following:

1. **Discovery Phase**: The initial step that sets the goals and objectives of the packaging project. By specifying the desired knowledge, the investigation begins which includes trend analysis, market research, information of the consumers and each environment where the package will be marketed or promoted. All these data are highly critical to define the strategic planning, which in combination with intuition is evaluated and the packaging brief is created, which reflects the visual language. These data as well as the strategy must be constantly reviewed.

2. **Creation Phase**: The brief is interpreted visually, resulting in a series of ideation and different concept solutions, which meet the expectations. Through this process a hierarchical list of messages is concentrated, including the features and benefits, which
communicate the vision, purpose, conflict, opportunities, acceptance and reception. All these lead to the development of various concepts, which explore different structures like color, linking elements, graphic architecture, photography and typography. The result of the phase is the selection of the best concept.

3. **Refinement Phase:** The design direction is now more effective and leads to the validation of options. The final package is approved and the preliminary sketches acquire a more tangible form. The integration of all stakeholders, as early as possible is very critical in identifying the constraints of production. The simulation of the package on the shelf as subjected to environmental factors, is also very significant in order to assess how the package is addressed by the consumer.

4. **Implementation Phase:** The objective of this phase is the selection of a unique design direction, if accepted by the customer, for the content and visual performance. It is possible at this stage changes or extensions to be made. Color variations even a variety of structures and formats are presented. The visualization of the concept includes full photography and 3D renderings.

5. **Production Phase:** The final phase of this process, which includes preparation of files in high resolution, color correction, production control, prototypes, and packaging style guides regarding the scale and placement of visual components and management of production resources.

### 3.6.3 Sustainable Packaging Design Models

As mentioned at the beginning of this chapter, there is a significant shortage on design processes that incorporate environmental factors in their models. However, is now widely accepted that environmental sustainability has begun to be considered an important goal for the industry, and this has given the impetus for further study.

A first reference is made to the models of Klooster and Olsmats, who in their studies consider environmental and resource efficiency, as significant attributes in packaging systems, and highlight the possible dispute between environment and economy. To underline the environmental impact, they are using the terms “packaging minimization” or “packaging waste
“Minimization”. However, the necessity to examine a products’ environmental prospect in a more systematic and holistic way, still exists. (Svanes, 2010)

Bucci and Forcellini, 2007, presented a Sustainable Packaging Design model in which incorporate environmental aspects from the very beginning of the process. It is about a generic model too, in which product and eco-design strategies and tools are involved in each stage of development. (Bucci et al., 2007)

As shown in the above diagram, there is an interdependence between product and packaging processes. Initially it is separated into three macro phases, the Pre-Development, Development and Post-Development which include the Packaging Strategic Planning, ConceptDesign, DetailDesign, Proving Functionality, Packaging Launch, and Packaging Review. (Bucci et al., 2007)
3.6.3.1 Sustainability Evaluation Tools and Methods

The sensitivity about the environment has often led companies to focus their attention on aspects such as the lightweight use of packaging per unit product, or the avoidance of materials that are considered detrimental for the environment. For that reason, several methods or tools have been proposed to assess the overall environmental impact of a product from cradle (raw materials obtainment and processing) to grave (waste process stage). (Svanes, 2010)

One of the leading evaluation methods of industrial systems, with scope to the full life cycle, i.e.

![Figure 19: Product Life Cycle. (Source: Solidworks)](image)

from the gathering of raw materials from the earth to create a product to the point that the material is back to earth, is the Life Cycle Assessment (LCA) method (see Fig. 19). It is about a standardized and widespread method, which first emerged in the 1960s, when concerns about the limitations of raw materials and energy resources, caused the need for the creation of a tool intended to calculate the use of material power during the manufacturing of a product. The LCA, is a linear approach, which is conducted in a purely quantitative framework and although time-consuming and complex, provides the most accurate and useful conclusions for the evaluation of materials and energy. (Bofylatos, 2011) The specific method focuses on function, which is its great benefit since the effectiveness of a product, for example the ability
to implement a specific function, is taken into consideration. (Svanes, 2010) Considering that all stages of a product's life cycle are interrelated, it provides a comprehensive picture of the environmental impact and not only those that occur at every step, but also includes those often not taken into consideration in other analyzes, focusing on the actual environmental significance of the choice of materials and production processes. (Bofylatos, 2011)

Another standardized tool that considers a wide range of requirements, is the Australian optimization tool PIQET that calculates many environmental impacts and is especially designed for the packaging industry. It was first launched in 2008 and is a streamlined approach to Lifecycle Assessments, which takes into account global warming, climate change, cumulative energy demand, photochemical oxidation, water use, solid waste and land use. Other properties of packaging that the specific tool evaluates include product protection, shelf-life and consumer awareness, i.e. labelling. (Svanes, 2010)

A different approach to the assessment of the package is the Scorecard method that was developed and implemented by the international retail company Wal-Mart. The company first announced this packaging initiative in 2006. It is a measurement tool, which all product suppliers of Wal-Mart are forced to use it to state their packaging system, and allows them to assess their packaging in relation to other suppliers. The indicators taken into account in the scorecard are gas emissions, material value, product/package ratio, cube utilization, transportation, efficiency, recycled content, recovery value, use of renewable energy and degree of innovation. All suppliers assume a total score compared with other suppliers, and the results with respect to each category. (Svanes, 2010)

### 3.7 The Anatomy of Packaging Design

In the field of marketing scientists and managers, is generally acknowledged that the form and aesthetics of a product, play a key role in consumer choice. So in the package the strategic use of visual stimuli, and all of these characteristics that contribute to the attractiveness, can provide a competitive advantage in the marketplace. (Mohebbi, 2014)
The packaging lifecycle may be small, but its main role, except to satisfy the requirement of use, is to communicate with the consumer as a means of expression, and reflect the spirit of the brand and its emotional value. Thus, as an extension of the product, characteristics such as form, color, trademarks, materials and structure are forming the “language” of the package, which is a mutual symbolic expression of the semantics of goods. (Wu et al., 2009)

In recent literature, there is increasing interest in the multisensory character of packaging design, too. Sensory properties, such as visual, tactile, auditory and even olfactory stimuli, as well as the meaning attached to, can determine consumers' emotions and affect their perception of the product. Hence, the exploitation of techniques from the field of experimental psychology and cognitive neuroscience can provide robust methods for choosing between alternative design solutions. (Spence, 2016)

This chapter provides an analysis of all the individual features that comprise a package, approaching them from marketing, semantics, consumer psychology and neuroscience point of view.

3.7.1 Color Attributes of Packaging

Color is one of the most important sensory characteristics of the packaging of a product, (Spence, 2016) as it is an ideal source of information that exercises significant influence in thoughts, feelings, and the behavior of consumers. (Mohebbi, 2014) For that reason, color has been used several times by marketers as “a mnemonic device to support cognition and thoughts” in order to attract consumers’ attention. (Labrecque et al., 2013) Due to the fast pace of modern life and the diversity of products, a strong color contrast or the use of activating colors, can have a significant impact on consumer behavior, their perception of the quality of the product, the visual appeal and purchase intention. (Mohebbi, 2014)
Kauppinen-Räisänen, (2014), in order to describe consumer behaviour, demonstrated a framework showing the color functions at the point of purchase, which are voluntary and involuntary attention, aesthetics and communication, as shown in the above diagram.

![Diagram showing the functions of packaging color at the point of purchase](figure20.png)

Figure 20: The functions of packaging color at the point of purchase. (Source: Kauppinen-Räisänen, 2014)

The color has of course and other applications in packaging design. A distinctive color, is commonly used to express the brand identity, which can achieve a direct correlation, after consistent use, e.g. the red of Coca Cola, blue of Barilla etc. (Calver, 2004)

In other cases, it is used as a visual discriminator, and in combination with other elements, creates different levels of comprehension for its differentiation from other competitors. Another application of color in packaging is the product differentiation in a particular brand range, so that consumers can identify more easily what corresponds to their needs. (Calver, 2004)

The selection of color should be based on the surrounding context, as there are no universal meanings and there may be cultural differences. (Spence, 2016) Designers should take into and observe these norms in the initial design stage, as consumers use to follow the color coding and expect it. (Calver, 2004)

Beyond the operational, aesthetic and decorative character of color, it has symbolic meaning too. Often the sense that derives from a color, has influence on visual and psychological feelings of the consumer and as a result that meaning becomes convention. For example, warm
colors such as red, make reference to the sun and fire and cause excitement, while cold colors indicate air water, rationalism and tranquility. (Wu et al., 2009)

Semantics in packaging, are usually associated with the experiences and physical stimulation of people who play an important role in the image of the product, as they reflect the character, mood and temperament of the product. (Wu et al., 2009)

The different meaning of colors in everyday life and in marketing, according to Singh and Srivastava (2011), are listed in the table below.

<table>
<thead>
<tr>
<th>Color</th>
<th>Connotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>celebration, purity, passion, strength, energy, fire, love, excitement, speed, heat, arrogance, ambition, leadership, masculinity, power, danger, blood, war, anger, revolution, and communism</td>
</tr>
<tr>
<td>Blue</td>
<td>depression, tranquility, trust, confidence, conservatism, dependability, wisdom, wealth royalty, truthfulness, and creativity</td>
</tr>
<tr>
<td>Green</td>
<td>growth, rebirth, renewal, nature, fertility, youth, good luck, generosity, health, abundance, stability, and creative intelligence</td>
</tr>
<tr>
<td>Yellow</td>
<td>sunlight, joy, earth, optimism, intelligence, hope, liberalism, wealth, dishonesty, weakness, greed, decay, aging, femininity, gladness, sociability and friendship</td>
</tr>
<tr>
<td>White</td>
<td>youth, sterility, light, reverence, truth, snow, air, cleanliness, coldness, fearfulness and humility</td>
</tr>
<tr>
<td>Black</td>
<td>absence, rebellion, modernity, power, sophistication, formality, elegance, mystery, style, evil, emptiness, darkness, seriousness, conventionality, unity, sorrow, professionalism, and sleekness</td>
</tr>
<tr>
<td>Gray</td>
<td>elegance, respect, reverence, wisdom, old-age, pessimism, boredom, decay, dullness, urban sprawl, intense emotions, balance, mourning, and neutrality</td>
</tr>
<tr>
<td>Orange</td>
<td>energy, heat, fire, playfulness, gaudiness, arrogance, warning, danger, desire, royalty, and religious ceremonies and rituals</td>
</tr>
<tr>
<td>Brown</td>
<td>calmness, boldness, depth, natural organism, richness, tradition, heaviness, poverty, dullness, roughness, steadiness, simplicity, dependability, friendliness and aids in stimulating appetite and is popularly used for advertising various bakery products, chocolates, foods and flavors</td>
</tr>
<tr>
<td>Pink</td>
<td>gratitude, appreciation, admiration, sympathy, socialism, health, femininity, love, marriage, joy, innocence, flirtatiousness, childlike behavior and symbolizes sweet taste</td>
</tr>
<tr>
<td>Purple</td>
<td>nobility, humility, spirituality, ceremony, mystery, wisdom, enlightenment, flamboyance, exaggeration, sensuality, pride, and lavender essence</td>
</tr>
<tr>
<td>Indigo</td>
<td>spirituality and intuition</td>
</tr>
<tr>
<td>Violet</td>
<td>elegance, grace and artistic creativity</td>
</tr>
<tr>
<td>Magenta</td>
<td>artistic creativity</td>
</tr>
<tr>
<td>Rose</td>
<td>optimism, hope and love and used in advertising to signify rosy flavors</td>
</tr>
</tbody>
</table>

Table 1: Connotations of Color in Daily Life and Marketing. (Source: Mohebbi, 2014)
3.7.2 Structural Attributes and Packaging Shape

Nowadays, structural design, allows a huge variety of options in packaging shapes and provide an "added value", which offers customized solutions to individual customer needs and brand differentiation. Transportation, warehousing, product handling, storage, display, merchandising, material selection and environmental considerations are some of the factors affecting the structural design and require deep knowledge of materials behaviour and tolerances, production methods and packaging technologies, especially in potentially harmful or sensitive to environmental factors products. (Calver, 2004)

Although many marketers consider that the packaging shape affects only the visual sense of consumers, there is also the opinion that tactile effects of the shape are much higher on expectations and consumer experience. (Spence, 2016) This view is supported further by the strong notion of "image mold", which is the silhouette of the contour of a shape, which is connected in the consumers’ mind with a particular product category or brand in general. One of the most powerful examples of all times, is the image mold of the Coca Cola bottle (see Figure 22), which was introduced in the market almost a century ago.

![Figure 22: (left) The Coca Cola bottle “image mold” (Source: personal archive), (right) The evolution of the Coca Cola bottle (Source: www.coca-colacompany.com)](image)

The multisensory experience of different packaging formats, has also been studied from neuroscience perspective, based on cross modal correspondence, explaining the influence of the curvature of a form, in various sensory properties, such as flavor and aroma. Evaluation
studies have concluded that the roundness and angularity of a packaging shape or brand logo is associated with sour or sweet taste of a product. (Spence, 2016)

From semantics point of view, different proportion, shape, scale, and composition, can provide a symbolic meaning and create a specific design atmosphere that gives consumers a psychological experience, a sense of familiarity and a more user friendly image. The structure of a package, may have either a regular or irregular shape. A normal square shaped container, is considered more robust and serious, creating feelings like responsibility calmness, elegance and clarity. On the other hand a regular circular shaped container is more vibrant, inclusive and harmonious and consumers may feel generosity. As irregular shapes are considered containers which have free curves as organic forms, and can provide a more simple and natural environment friendly feel. Smooth curves can indicate relaxation or intensity, strength or clemency, and asymmetry can cause more innovative sentiments. (Wu et al., 2009)

3.7.3 Packaging Texture Attributes

In packaging design, the “representation” of texture, has a direct correlation with material selection and is considered one of the most important features that contribute to the overall multisensory experience of products. (Spence, 2016) Some of the material selection factors, besides safety and efficiency, which are assessed by strength of materials, wear resistance and physical protection, is also the visual and tactile perception that provide to consumers the psychological correlation of sensation while handling the package. (Wu et al., 2009)

Despite the importance of texture in design, is still considered unexplored, and little studies have been made in focus groups, about how the texture can affect the consumer experience, particularly in products which are consumed directly from the package, either positively or negatively. Results have shown that the roughness or softness of packaging is directly related to the sensation of food texture. (Spence, 2016) More generally, the “rendering” of a particular texture may even express the quality of the goods. In cases requiring a more natural feel, materials such as bamboo, wood, rattan are able to support it. When the consumer desires a more high tech and mysterious package, metallic materials are most suitable, while injection
molding plastics, enable a matte surface which leaves a beautiful sense and are ideal for cosmetics. (Wu et al., 2009)

However the quality and performance of the texture directly influences the tactile image of the goods. (Wu et al., 2009) An interesting and distinctive surface finish may encourage consumers to approach a specific package more easily on the shelf, to attract them to touch it and distinguish it, thus acting as an effective marketing tool. Unfortunately an unconventional texture, very often increases the final cost of production, element discouraging for manufacturers. (Spence, 2016)

3.7.4 Graphic Design Elements and Branding in Packaging Design

Apart from the elements mentioned above, such as color, shape, surface and texture, there are other components that their objective is to convey messages. These are graphic elements like trademarks, patterns, text and explanations, and in conjunction with the above, contribute in the configuration of a broader visual design language and brand image. (Wu et al., 2009)

In an era when the strength of the brand is huge, its projection on the package, which usually occupies the front view, indicates ownership and serves to its recognition from consumer during the evaluation and selection process. The logo or symbol of the brand, is the most effective way of differentiation mainly because of its uniqueness, which is legally protected. However the logo is not the only element, as the brand identity is also formed by the color palette, typeface family, imagery, tone of voice etc. To achieve this goal, it must maintain a certain design attitude that includes all graphic elements (Calver, 2004) which follow a design rule so that it is identifiable in accordance with a general visual style. In this case, a visual language guide can be effective, in order to ensure consistency in the possible abstract visual perception of all elements. For example, a circular shape gives the impression of perfection while a square implies stability. Where photos, illustrations and decorative patterns are used, it is important to convey the same language intuitively. (Wu et al., 2009)

Communication of brand personality can be attributed even with different printing techniques, such as embossing, debossing, foiling, or varnishing. (Calver, 2004) Choosing the right font is
equally important and refers to a special character. For example, if the product is classic or contemporary, functional or sincere, handmade or manufactured, the font can contribute to this. As well as the font effects like boldness or delicacy or individual details as ligatures, ascenders, spurs or loops. (Wu et al., 2009)

3.7.5 Information Design in Packaging

Graphic design, as a part of packaging design, may be especially important, but their main role is to disseminate information and help the communication between messages. Each product can be identified by the name, description, use, benefits, components, ingredients, instructions, warnings, safety, customer care information, and ownership details. It is necessary, the information on each package to appear in a range of foreign languages because of globalisation. These texts need to be placed in such a way that it is simple and legible to consumers and give them the opportunity to recognise the information that they finally need.

The topographical options may be many, but must be corresponded with each desired function. Some important factors that determine the choice of any desired font are the pack size, information extent and printing methodology. The choice of each font can be influenced by the need of differentiation and lead in creating a new one. (Calver, 2004)

In any case it is very important to bear in mind that each font can express different semantics. These semantics reflect the classical culture, serenity, simplicity, dignity and stability, which each product wants to transmit. For example, pharmaceutical and medical products usually support the bold and strong characters, which express safety and confidence. In contrast, in women's cosmetics are usually selected thin and soft characters, which show the beauty and elegance of the audience. Usually, in household appliances classification used strong and modern types of characters. Finally, food packaging and products for children using round-shaped font characters. (Wu et al., 2009)
3.7.6 Ergonomics in Packaging Design

Reliability and saving money, are not the only requirements of consumers, but also safety, convenience and comfort when using the product. (Berns, 1981) The prevailing belief among consumers is that a difficult package during opening is associated with higher product quality. (Spence, 2016) The problems that consumers are facing due to packaging are serious and should be taken into account by designers. This is evidenced by the large number of injuries faced by consumers and are mainly because of the difficulty in opening a package. (Spence, 2016) These problems can be divided into two categories which are dependent from one another in particular the information on the package itself, and the handling of the package. This information is very important to be designed in a certain way, so that the form is consistent with the content, according to intended use and enhance comfort and reduce errors in the most intuitive way possible. Handling problems are associated with the physical skills as strength and dexterity. (Berns, 1981)

Ease of opening can influence the consumer experience, even if he realizes it or not. An important reason that aggravate the openability is the trend in the use of several layers, in order to give the impression to the consumer that he opens a gift. (Spence, 2016) Some other important design factors are the shape, size, weight, surface finish, visual and opening devices. Especially, the shape can influence the consumer's intention to read the instruction labels. (Winder, 2002) Therefore, some of the operational requirements of consumers that should be taken into account are not only the ease of opening, emptying and re-closing, but also the good design of informative labels, child resistance properties and reduction of bulky garbage. (Berns, 1981)

Ergonomics therefore plays a very important role in the packaging design process in order to facilitate as much of the population as possible. A large and growing proportion of the population are the elderly and the disabled, who are requested to face up to the packaging difficulties of consumer goods and is very important for them to be self-sufficient, especially in their personal hygiene and food preparation. (Berns, 1981) Equally important is the factor
“handness”, where frequently the asymmetrically packages that require grasping and pouring, cannot be used by left-handed. (Spence, 2016)

Finally, in order to reduce accidents caused by opening a package, it is important to study the reasons of the cause, but also the type of material. Usually they are caused by the use of a tool like sharp knives, throwing glass objects at the opening, the use of excessive force in the effort, the sharp edges mainly in canned products and use of dangerous practices in general. (Winder, 2002)

3.7.7 Sustainability Concerns of Packaging

Environmental concerns have become one of the most important goals in industry and affect both manufacturing and merchandising. Apart from the fact that for many companies is part of their social responsibility, in most countries very strict legislations are followed. (Calver, 2004) The aim of the environmental policy is the reduction of waste, particularly for secondary packaging such as cartons and to enhance reuse and recycling of materials. (Rundh, 2005)

From the consumer aspect, the sense of environmental protection has also increased, thus requiring from manufacturers more environmental friendly packaging. This has an impact even in the marketing of products where consumers are increasingly seeking for eco-labels in the evaluation of their choice. (Calver, 2004)

Sustainability of packaging is a key factor in design decisions as focuses throughout the life cycle of the packaging, particularly in matters related to energy consumption, choice of materials, the fuel costs in transportation, production methods, disposal capability, and environmental impact. The packaging design is still affected by recycling mainly in selection of materials. There are plastics such as (PET) Polyethylene Terephthalate, which allows the recycling and others such as Polystyrene, which is normally unable to be recycled, while the use multiple layers further complicates such use. (Calver, 2004)

The final design result may be determined by several factors, such as cost, the responsibility of the customer and the design brief, but the role of packaging designer is determinant and his
knowledge on environmental issues, is what can change the perception mainly in the choice of materials. (Calver, 2004)
4. Toothpaste Packaging Design Proposals

This chapter begins with a description of the methodology followed, and all the data so far reported in the theoretical part of the work are recovered with the aim of creating different design proposals presented below.

4.1 Methodology

For the purpose of conducting this thesis, a small simulation of the design process is carried out and therefore it is not possible to implement all the stages described above in the proposed methodologies. As we can conclude in the case of toothpaste, the package could be treated purely as a product, as the user comes into direct contact and interact with it throughout its entire lifecycle. For the aforementioned reasons, the methodology that has been followed, is based mainly on the Product Development Design Process models presented before, and more specifically taking as a reference point the Design Cycle of Roozenburg and Eekels, combined with some elements from other processes. However, a more intuitive approach through the simplification of the procedures is used, with greater emphasis primarily in the creative stage and the creation of tools which take into account the factor of innovation, in order to discover a pool of design opportunities.

More specifically, the Analysis Stage presented in the two previous chapters, included:

- Comparative analysis of current types of packaging based on surveys.
- Research on toothpaste protection requirements according to FDA legislations and on materials and recycling technologies in order to record the limitations.
- Determination of functional problems and confirmation of research results through:
  - Testing of different products to compile a bugs list
  - Painstorming Technique to identify inconveniences
  - Observation of the operating environment of different users
  - Analysis of the toothbrushing process
Brief interviews with users
- Study of the theoretical background in Chapter 3, which is a benchmark for the design decisions and evaluation of possible solutions to the next stages.

The Analysis Stage was completed with the determination of the **Mission Statement**, where the statement of the design problem defined the **Design Brief**, while the problems translated into **Design Requirements**, and the market research led to the definition of the **Target Group**.

With the **Synthesis Stage**, begins the Generation of the Concepts, while the steps and tools used are:

- Ideation through brainstorming and mapping of the ideas
- Decomposition of the design problems into sub solutions
- Coded visual representation of possible solutions and recording them in a table, the combination of which results in different concepts

The **Evaluation Stage** was repeated several times in order to:

- Initially filter solutions for further development of concepts
- Evaluate the structural study based on requirements
- Test the functionality thought physical mock ups

Finally the **Simulation Stage** included:

- Virtual creation of brands to boost the development process of the concepts
- Visual representation through 3D renderings
- Sustainability simulation for the material selection and their evaluation

The results of the process are presented below.
4.2 Project Mission Statement

At this point it is important to mention that the objective of this thesis is not the redesign of a particular commercial brand. As mentioned in the theoretical part that preceded, the brand identity plays an important role in the formulation of the final package and therefore it was deemed necessary to create different virtual brands, for the presentation of a more integrated design process.

4.2.1 Design Brief

The design brief of the specific project stems from the extensive research stage of the existing toothpaste packaging and is defined as: “The design of a flow control system of viscous materials, in this instance of the dentifrice, in order to facilitate the process of teeth brushing and upgrade the existing packaging for a more accurate use.”

More specifically, the design goals of this process are:

- the development of a packaging that follows a sustainable approach.
- the optimization of the extrusion mechanism of the material.
- the improvement of the aesthetic aspect of the packaging, which follows the design guidelines of the brand.

4.2.2 Stakeholders and target group

Oral hygiene and therefore teeth cleaning, is undoubtedly a necessary process for the everyday routine of all people, irrespective of gender, age and nationality. However each person has different needs, depending on the dental problems may be faced in the oral cavity, such as decay, plague, enamel erosion, bad breath, dentin sensitivity or whitening control, which does not affect the pattern of the washing process, but product differentiation according to needs is a factor to be considered during the design of the package. Furthermore, dental problems mentioned above could perhaps be associated with age and therefore, combined with psychographic attributes the segmentation of the target market could be based on different age groups, in the following categories:
✓ Children - where the design of a more attractive packaging can be an incentive to wash their teeth in a more entertaining manner or may be difficult to do without the guidance of their parents.

✓ Young Adults - who may be influenced by the modern lifestyle and trends.

✓ Adults and Middle Aged - which usually require solvency and confidence in their choices.

Users could also be separated in other two categories based on their lifestyle, to those who spend most of their daily life away from home or travel frequently and those who wash their teeth exclusively in their residence area.

For the purpose of this thesis there is an attempt to cover as wide part of buyers as possible while dental professionals are not taken into consideration.

4.2.3 Design Requirements

At this point, there has been an effort so that the problems extensively been analyzed in the first chapter, to be translated into design specifications. The simultaneous satisfaction of all the design guidelines is a major challenge in the design process as there may be conflicting features which are not feasible to be compatible. Nevertheless, we can observe that several requirements interact with each other and can also affect design decisions. In the following table, these requirements have been recorded, and divided into four basic categories, based on functionality, ergonomics, sustainability and aesthetics, so that it becomes easier to understand user needs, and they are presented in a hierarchical order so that later can become an essential criterion in the concept selection stage.
# DESIGN REQUIREMENTS

## FUNCTIONALITY
- Maintain the product fresh
- Ability to stand up
- Stability
- Possibility of Controlled Dosage
- Reduce UPR levels (facilitate emptying)
- Re-closability
- Avoid accidental losing the lid
- Safety lock
- Range of sizes based on needs
- Travel size – Portability
- Modularity – space saving (enhance stacking, warehousing, shelf display and transportation)

## ERGONOMICS
- Minimizing required force
- Ergonomic grip – stable holding
- Ability to use with one hand
- Ease of opening – closing
- Facilitate left – right hand use
- Prevent slipperiness
- Intuitive use
- Narrative Instructions
- Indicate residual quantity
- Differentiation of product range

## SUSTAINABILITY
- Avoid over-packaging
- Use of sustainable materials
- Recyclability
- Reusability
- Reduced waste bulk
- Possibility of cleaning residues of container
- Facilitate disassembly for material separation

## AESTHETICS
- Harmonization with bathroom environment
- Differentiation from competitive products
- Follow packaging trends
- Make fashion statement
- Natural – Eco Aesthetic
- Provide a sense of purity and freshness

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Table 2: List of Design Requirements
4.3 Concept Generation

4.3.1 Ideation

For the creation of the initial concepts, some tools were used in order to enhance the creative process and trigger the generation of new ideas. In this early phase, the brainstorming technique was employed, while an attempt for mapping these ideas, as shown in the diagram below, with central axis the design requirements mentioned above. At this point, it is important to mention that the decomposition of the main problem and the treatment of each sub problem separately, was particularly helpful to propose solutions which lead to the creation of initial ideas.

![Image: Brainstorming - Mind Map.](image)

Figure 23: Brainstorming - Mind Map.
Subsequently, a visual representation of the proposed solutions presented in the mind map above, was carried out with the ultimate aim to be further interpreted and to study the possibility of their achievement. Inspiration was drawn from either various existing mechanisms, either by nature and created a fertile ground for the study of more specific characteristics that can contribute to the creation of an integrated concept as structure, form, color, texture, materials, as well as aesthetic qualities.

The results of this procedure are presented below in a coded manner so as to avoid the risk of stagnation at a specific concept, so that it becomes possible to produce several divergent ideas, through the combination of the individual solutions and the prospect of introducing the innovation component.
4.3.2 Presentation of the Selected Concept

The main objective and concern, on which the idea of the proposed design concept was based, as stated above in the design brief, is to improve the operating mechanism of the toothpaste. In order to accomplish this, several tests were conducted and many combinations of the proposed solutions were created, some of which were rejected by the hierarchy of the design requirements or because some solutions of these contradicted some other design guidelines, such as the ability to use with one hand, which is particularly important for the smooth operation of the toothbrushing process. Hence the selected concept which meets the majority of design requirements is based on the piston mechanism.

Some of the advantages offered by this mechanism in general are the following:

- the required strength of the piston stays constant throughout the following path
- the flow velocity can be maintained constant

Table 3: Concept Combination Table.
The above scheme illustrates the operation of the basic idea of the main mechanism on which the development of final concepts is based, which will be presented in details, in subsequent subchapter. This mechanism consists of the main vessel which is open at the bottom and is filled with toothpaste. The providing of the dentifrice is extracted from the vessel with the aid of a piston, following the movement on the shifting axis, from position 0 to position 1, as shown in section above. The piston has bonded to its surface, a rubber component which assists by friction with the walls of the container, the extrusion of the dentifrice abroad and simultaneously provides the airtight seal of the container. In this manner the design enables the user to exploit the
entire product, by reducing the wastage (UPR levels), without requiring much human effort. The piston in turn, has a button extruded from the side surface which slides between the slit that is formed at the side of the container. At the same time the sliding button could function as an indication of the amount of toothpaste remaining in the container. Finally, to protect the product from contact with ambient air, the slot could be airtight with an aluminium foil, which will tear gradually during the upward movement of the sliding handle.

The following sketch depicts the manner of use of that mechanism and its interaction with the user.

Figure 25: Conceptual Sketch of the Use of the Main Proposed Mechanism.
4.3.3 Conceptual Structures

With the completion of the above step, the solution of most operational problems of the design process ended as well. However, at this point, it was necessary to return to the stage of design requirements in order to provide feedback on possible revision and examine, through quantitative analysis the degree of satisfaction of these criteria.

The next step which has been studied is the investigation of the morphological features of the object under design. If we look back in the aforementioned tables of design requirements and the individual sub solutions, we can conclude that the criteria that primarily affect the structural elements of the packaging are mainly ergonomic. Some of them are steadiness of holding, left- right hand usage, minimization of slipperiness and intuitive use. From the perspective of sustainability, the recyclability also played an important role as a key condition was the cleaning capability of residues, disassembling for separating materials and the possibility of reusing the outer case by replacing the spare part. Finally, as has been repeatedly reported in the theoretical part of this thesis, a key factor that affects the aesthetics when designing a package is the brand identity. For the reason that is not set as a target in the design brief, the redesign of a commercial brand, alongside with the conceptual structure investigated the prospect of creating a virtual brand, the design language of which could reflect and aesthetical criteria.

The following figure shows the exploration of different structural concepts and the inspiration drawn either by nature or from objects of art or the aesthetics communicated from perfume bottles, as well as the upgrading of aesthetics of toothpaste could be accomplished in this manner, to achieve the harmonization with the bathroom environment.
Figure 26: Conceptual Structure Sketches.
4.3.4 Concept Testing

Based on the criteria mentioned above, arose the selection of the structural concepts for further analysis. For the better understanding of the form and in order to test their operating method and ergonomic usability, physical models created from plasticine, as shown in the following figure.

This process was particularly fruitful to study the scale and dimensions of the proposed objects, make the appropriate refinements and begin the development process and the detailed design of the concept, as well as their realistic imagery that will be presented in the next chapter.

Figure 27: Physical Mockups and Concept Testing.
4.4 Concept Development

4.4.1 First Concept – “Say Cheese!”

The brand name chosen for the design of the first concept is “Say Cheese!” and is an alternate way, especially popular among photographers, to ask someone to smile. The objective of the specific brand is to transmit a playful experience for younger audience and this is achieved by providing a modern look that is relevant to comic aesthetics. The message which is communicated through the design of graphic elements is the uniqueness that each individual human smile has. This uniqueness of the human denture as illustrated graphically, also serves to diversify the range of products of the same brand. This differentiation is also achieved by the use of strong and saturated colors, while further enhances the funny and relaxed mood that the brand tries to promote while contributing to a more eye-catching result, in comparison with competitors, as selected colors vary considerably from those used so far in the toothpaste market.
In the rendered picture above, the implementation of brand is presented visually on the packaging and some structural elements of the package can also be observed. The selected form is characterized by simplicity and contrasts with the loud aesthetic of the brand, in order to achieve a balance.
4.4.2 Second Concept – “Dental Fresh”

The name of the second brand under investigation is “Dental Fresh” and the visual communication could be considered more conventional because design is closer to the style and aesthetics of classical toothpaste packages, as most people have in their minds, whilst the graphic references clearly refer to the content of the package. The specific aesthetic was intentionally chosen in order to place more emphasis on morphological elements of the package. The selected colors also follow the color palette of the content, and the communication of the aesthetical requirements is achieved in this manner, which are the sensation of freshness, purity, cleanliness and environmental friendliness.
Regarding the structural elements of the package, an attempt was made to further improve the ergonomic factor, compared to the previous idea so as to mainly foster their stability to hold during use. The visualization of the results are shown in the above rendered image, while for the outer casing transparent materials were selected in order to attract the interest of the public, and additionally for the label to be evident which has been applied to the surface of the interior part of the container.
4.4.3 Third Concept – “Sparkle”

The name chosen for the third brand is “Sparkle” and refers symbolically to the shiny effects which might have the use of the specific toothpaste. The brand image of this idea is further strengthened by means of graphic elements which sought to create the sensation created by light reflection when incident on shiny surfaces such as water, through the use of geometric abstraction and different hues of the same color. Inspiration is drawn from pixel art in order to be ascribed effectively with abstract way the glowing effect.

As shown in the picture below product differentiation is accomplished chromatically and more vivid, “RGB” colors are selected, which make high contrast with the white background.

Morphologically, the aerodynamic shape of the package follows the design language of the brand and the notches on the right side of the package serve as a handle for better grip during use and avoid slipperiness.
Figure 33: Rendered Image of Sparkle Concept and Product Range Differentiation.
4.4.4 Forth Concept – “Crystalline”

The last proposed brand is named “Crystalline” and is intended to convey a sense of crystal coolness. The unusual design of the outer case, as the name implies, is inspired by the structure of crystals, while the minimalist design of the logo attempts to promote a superior quality of the product. For the design of the label, a pattern consisting of divided triangular geometric forms was created, of which the logo is formed, too. Chromatically, an attempt was made to reflect the iridescent glow of crystals with different caps used for product range differentiation.

Morphologically, as shown in the next image, the asymmetry of the structure of the crystals was utilized except from aesthetical reasons, for the further improvement of the ergonomic gripping of the package.

Figure 34: Crystalline Concept – Brand Identity.
Figure 35: Rendered Image of Crystalline Concept and Product Differentiation.
4.5 Detailed Description of the Concept Parts

As we can observe in the above picture that illustrates an exploded view of the assembly, all the proposed concepts consist of 4 basic features. The lid, the inner vessel that contains the toothpaste, the outer casing which protects the product, and the sliding button that forces the toothpaste to extrude from the inner vessel. These parts are detachable in order to facilitate the recycling process.

The design in order to enable the user to exploit the entire product, by reducing the wastage, without requiring much human effort, is based on the concept of the syringe, which is described in detail in Chapter 4.3.2. It consists of the main vessel which is open at the bottom and is filled with toothpaste. The providing of the dentifrice is extracted from the vessel with the aid of a piston. The piston has bonded to its surface, a rubber component which assists by friction with the walls of the container to promote the dentifrice abroad and simultaneously provides the airtight seal of the container. The piston in turn, has a button extruded from the side surface which slides between the slit that is formed at the side of the container. At the
same time the sliding button could function as an indication of the amount of toothpaste remaining in the container.

To protect the product from contact with ambient air, the slot could be airtight with an aluminum foil, which will tear gradually during the upward movement of the sliding handle.

The mouth of the container has the necessary threads to screw the cap. In addition to this, the lid is either hinged or screwed cap so that during use to be reclosable.

The outer casing, has the specific structures not only for aesthetical reasons, but is designed in a way to ergonomically fit to the hand of the user.

Eventually, at the outer casing two thin strips of silicon are attached, which provide additional protection from air and by means of friction enable the movement of the slide button to be more controllable.

More details about the designs and the dimensions of each concept can be found at the appendix, in Part B.
4.6 Sustainability Evaluation

All the individual parts of the proposed concepts are designed to be from plastic materials but in order to evaluate the sustainability the Forth Concept was selected as seems to be the most promising and due to the fact that it has the most complicated geometry. In order to select the most eco-friendly materials, a Sustainability analysis has been performed in Solidworks, and the results are going to be presented in this sub chapter.

Due to the geometric conditions of the designed product, we can predict in advance that the manufacturing method that will be used to produce the specific design, is injection molding.

The category of materials which will be studied in the specific design are thermoplastics. A Thermoplastic, or Thermosoftening plastic, is a plastic material, polymer that soften when heated (and eventually liquefy) and harden when cooled, processes that are fully reversible and successive. At the molten phase (which usually involves both heat and pressure), the malleability of the materials help them without difficulty to be formed into another structure. During the process of cooling they are transformed into a solid state and this is their final shape. Repeated heating cycles are permitted, and for this reason can be recycled or reprocessed.

In some cases, the amorphous attributes of thermoplastics can be preserved, due to the fact that during the lower limit of glass transmission temperature Tg, are not able to thoroughly crystalize. As a result there are two categories of thermoplastics, the amorphous and the semi amorphous which are used on case there is a requirement for optical transparency since the crystallite by which is formed, is able to scatter the light. Both categories of plastics are vulnerable to chemicals and fracture due to stress factors because of their disability to form crystalline structure. (“Thermoplastics”, 2016)

Some of the positive and negative attributes of thermoplastics are as follows: (“Identifying Recyclable Resources”, 2017)

Advantages of Thermoplastics

✓ Present high impact strength values
✓ Excellent Appearance and refined surface finish
✓ Able to be recycled and the scrap is reusable
✓ They have no emissions
✓ Able to bond with other thermoplastic materials
✓ With heat are able to be re molded or re shaped

Disadvantages
✓ In general they can easily soften with the aid of heat
✓ The prototype is not easily formed

In the Appendix there is a brief reference of the most common types of thermoplastics commercially available, on which the selection the material were conduct based on the design requirements.

4.6.1 Solidworks Sustainability Report Results of the Individual Parts

In order to run the Environmental Analysis in Solidworks, Thessaloniki, Greece is set as the manufacturing region, and Rome, Italy, the area were the product will be placed on market. The distance is about 1945 km, and the transfer will be done by truck.
For the design of the lid, after a brief research, there are two candidate materials, Polypropylene and Low Density Polyethylene, which have the most appropriate mechanical properties. LDPE is flexible and tough enough, whereas PP has high stiffness, good impact balance, high gloss appearance and good hinge properties since it is fatigue resistance, making it more suitable for the hinged lid. After the study of the Life Cycle Assessment of the two materials we can conclude that PP is more sustainable, although it has greater financial impact. If we compare the results of the charts below we can observe that PP has sufficiently improved the design. The total measurements of carbon-dioxide and other greenhouse gas emissions are estimated to be 0.011 kg. The second charts provides detailed description of the non-renewable energy sources used during the parts lifecycle and it is estimated to 0.271 MJ. The Air Acidification is related with the emissions of sulfur dioxide and nitrous oxides that are responsible for the acidity of rain water, and is calculated to be 3.4E-5 kg. On the other hand, water eutrophication which concerns the overabundance of nutrients like nitrogen and phosphorous from waste water to the ecosystem, is measured to be 4.0E-6 kg.
# Environmental Impact Comparison

## Carbon Footprint - Comparison

<table>
<thead>
<tr>
<th>Total</th>
<th>PP Copolymer : 0.011 kg CO₂e</th>
<th>PE Low/Medium Density : 0.014 kg CO₂e</th>
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<th>Material</th>
<th>New Design: Better 0.011 kg CO₂e</th>
<th>Original Design: Baseline 0.014 kg CO₂e</th>
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<td>Manufacturing</td>
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<td>6.6E-3</td>
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<td>Use</td>
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<td>3.0E-3</td>
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<td>End Of Life</td>
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<td>1.9E-3</td>
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<tr>
<td>Transportation</td>
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</table>

## Total Energy Consumed - Comparison

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<th>PE Low/Medium Density : 0.289 MJ</th>
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</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>New Design: Better 0.271 MJ</th>
<th>Original Design: Baseline 0.289 MJ</th>
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<td>0.058</td>
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<td>End Of Life</td>
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<td>1.4E-3</td>
</tr>
<tr>
<td>Transportation</td>
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<td>3.9E-3</td>
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</table>

## Air Acidification - Comparison

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<th>PE Low/Medium Density : 3.6E-5 kg SO₂e</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>New Design: Better 3.4E-5 kg SO₂e</th>
<th>Original Design: Baseline 3.6E-5 kg SO₂e</th>
</tr>
</thead>
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<tr>
<td>Manufacturing</td>
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<td>1.4E-5</td>
</tr>
<tr>
<td>Use</td>
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</tr>
<tr>
<td>End Of Life</td>
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<tr>
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<td>1.2E-6</td>
<td>1.2E-6</td>
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## Water Eutrophication - Comparison

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<th>PE Low/Medium Density : 5.8E-6 kg PO₄e</th>
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<table>
<thead>
<tr>
<th>Material</th>
<th>New Design: Better 4.0E-6 kg PO₄e</th>
<th>Original Design: Baseline 5.8E-6 kg PO₄e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>1.1E-6</td>
<td>1.2E-6</td>
</tr>
<tr>
<td>Use</td>
<td>7.2E-7</td>
<td>7.4E-7</td>
</tr>
<tr>
<td>End Of Life</td>
<td>1.9E-6</td>
<td>1.9E-6</td>
</tr>
<tr>
<td>Transportation</td>
<td>2.7E-7</td>
<td>2.8E-7</td>
</tr>
</tbody>
</table>

## Material Financial Impact Comparison

<table>
<thead>
<tr>
<th>Material Financial Impact Comparison</th>
<th>New Design: Better 0.01 USD</th>
<th>Original Design: Baseline 0.01 USD</th>
</tr>
</thead>
</table>
## Outer Case

For the design of the outer case, the same materials with the lid were selected, Polypropylene and Low Density Polyethylene, since the requirements for the mechanical properties are the same and the factor of non breakability is very crucial in order to achieve the reusability and durability for longer lifespan. If we compare the results of the charts below we can observe that PP has sufficiently improved the design. The total measurements of carbon-dioxide and other greenhouse gas emissions are estimated to be 0.032 kg. The second charts provides detailed description of the non-renewable energy sources used during the parts lifecycle and it is estimated to 0.0824 MJ. The Air Acidification is related with the emissions of sulfur dioxide and nitrous oxides that are responsible for the acidity of rain water, and is calculated to be 1.0E-4 kg. On the other hand, water eutrophication which concerns the overabundance of nutrients like nitrogen and phosphorous from waste water to the ecosystem, is measured to be 1.2E-5 kg.

### Model Name

<table>
<thead>
<tr>
<th></th>
<th>BackCaseBody</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model Name:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Material:</strong></td>
<td>Current</td>
</tr>
<tr>
<td><strong>Recycled content:</strong></td>
<td>0.00 %</td>
</tr>
<tr>
<td><strong>Weight:</strong></td>
<td>8.42 g</td>
</tr>
<tr>
<td><strong>Manufacturing process:</strong></td>
<td>Injection Molded</td>
</tr>
<tr>
<td><strong>Surface Area:</strong></td>
<td>193.19 cm²</td>
</tr>
<tr>
<td><strong>Built to last:</strong></td>
<td>1.0 year</td>
</tr>
<tr>
<td><strong>Duration of use:</strong></td>
<td>1.0 year</td>
</tr>
<tr>
<td><strong>Material Unit Cost</strong></td>
<td>2.80 USD/kg</td>
</tr>
</tbody>
</table>

### End of Life

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recycled:</strong></td>
<td>25 %</td>
<td>25 %</td>
</tr>
<tr>
<td><strong>Incinerated:</strong></td>
<td>24 %</td>
<td>51 %</td>
</tr>
<tr>
<td><strong>Landfill:</strong></td>
<td>51 %</td>
<td>24 %</td>
</tr>
</tbody>
</table>

### Manufacturing

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electricity consumption:</strong></td>
<td>1.8 kWh/lbs</td>
<td>1.8 kWh/lbs</td>
</tr>
<tr>
<td><strong>Natural gas consumption:</strong></td>
<td>0.00 BTU/lbs</td>
<td>0.00 BTU/lbs</td>
</tr>
<tr>
<td><strong>Scrap rate:</strong></td>
<td>2.0 %</td>
<td>2.0 %</td>
</tr>
</tbody>
</table>
Environmental Impact Comparison

<table>
<thead>
<tr>
<th>Environmental Impact</th>
<th>New Design: Better</th>
<th>Original Design: Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Footprint</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP Copolymer</td>
<td>0.032 kg CO₂e</td>
<td>0.824 MJ</td>
</tr>
<tr>
<td>PE Low/Medium Density</td>
<td>0.041 kg CO₂e</td>
<td>0.878 MJ</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Material              | 0.017               | 0.020                      |
| Manufacturing         | 9.0E-3              | 9.2E-3                     |
| Use                   | 0.00                | 0.00                       |
| Transportation        | 7.7E-4              | 7.9E-4                     |

| Air Acidification     |                     |                            |
| Total                 |                     |                            |
| PP Copolymer          | 1.0E-4 kg SO₂e      | 1.2E-5 kg PO₄e             |
| PE Low/Medium Density | 1.1E-4 kg SO₂e      | 1.8E-5 kg PO₄e             |
| Total                 |                     |                            |
| Material              | 3.7E-5              | 3.4E-5                     |
| Manufacturing         | 6.0E-5              | 6.2E-5                     |
| Use                   | 0.00                | 0.00                       |
| End Of Life           | 3.3E-6              | 3.4E-6                     |
| Transportation        | 3.6E-6              | 3.7E-6                     |

| Water Eutrophication  |                     |                            |
| Total                 |                     |                            |
| PP Copolymer          | 1.0E-4 kg SO₂e      | 1.2E-5 kg PO₄e             |
| PE Low/Medium Density | 1.1E-4 kg SO₂e      | 1.8E-5 kg PO₄e             |
| Total                 |                     |                            |
| Material              | 3.7E-6              | 3.7E-6                     |
| Manufacturing         | 2.2E-5              | 2.2E-5                     |
| Use                   | 0.00                | 0.00                       |
| End Of Life           | 5.7E-6              | 5.9E-6                     |
| Transportation        | 8.2E-7              | 8.4E-7                     |

Material Financial Impact

| New Design:        | 0.02 USD            |
| Original Design:   | 0.02 USD            |

Note: The values represent the impact in metric tons for CO₂e and kilograms for SSO₂e and PO₄e.
**Inner Vessel**

<table>
<thead>
<tr>
<th>Model Name:</th>
<th>Inner vessel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Material:</strong></td>
<td>PE High Density</td>
</tr>
<tr>
<td><strong>Recycled content:</strong></td>
<td>0.00 %</td>
</tr>
<tr>
<td><strong>Weight:</strong></td>
<td>12.51 g</td>
</tr>
<tr>
<td><strong>Manufacturing process:</strong></td>
<td>Injection Molded</td>
</tr>
<tr>
<td><strong>Surface Area:</strong></td>
<td>267.44 cm²</td>
</tr>
<tr>
<td><strong>Built to last:</strong></td>
<td>1.0 year</td>
</tr>
<tr>
<td><strong>Duration of use:</strong></td>
<td>1.0 year</td>
</tr>
<tr>
<td><strong>Material Unit Cost</strong></td>
<td>2.20 USD/kg</td>
</tr>
</tbody>
</table>

**End of Life**

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycled:</td>
<td>25 %</td>
<td>25%</td>
</tr>
<tr>
<td>Incinerated:</td>
<td>51 %</td>
<td>24%</td>
</tr>
<tr>
<td>Landfill:</td>
<td>51 %</td>
<td>24%</td>
</tr>
</tbody>
</table>

**Manufacturing**

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity consumption:</td>
<td>1.8 kWh/lbs</td>
<td>1.8 kWh/lbs</td>
</tr>
<tr>
<td>Natural gas consumption:</td>
<td>0.00 BTU/lbs</td>
<td>0.00 BTU/lbs</td>
</tr>
<tr>
<td>Scrap rate:</td>
<td>2.0 %</td>
<td>2.0 %</td>
</tr>
</tbody>
</table>

**Comments**

For the inner vessel, the initial material for the test was PVC. After several tests with materials that have similar properties, we can conclude that HDPE, has improved the environmental impact of the design. It worth mentioning that the total energy consumption for both materials is approximately the same, since the energy required for the material procurement is slightly worse, while for the manufacturing processes the results are better.
### Environmental Impact Comparison

#### Carbon Footprint - Comparison

<table>
<thead>
<tr>
<th></th>
<th>New Design:</th>
<th>Original Design:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>PE High Density: 0.046 kg CO₂e</td>
<td>PVC Rigid: 0.069 kg CO₂e</td>
</tr>
</tbody>
</table>

#### Total Energy Consumed - Comparison

<table>
<thead>
<tr>
<th></th>
<th>New Design:</th>
<th>Original Design:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>PE High Density: 1.2 MJ</td>
<td>PVC Rigid: 1.2 MJ</td>
</tr>
</tbody>
</table>

#### Air Acidification - Comparison

<table>
<thead>
<tr>
<th></th>
<th>New Design:</th>
<th>Original Design:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>PE High Density: 1.5E-4 kg SO₂e</td>
<td>PVC Rigid: 2.3E-4 kg SO₂e</td>
</tr>
</tbody>
</table>

#### Water Eutrophication - Comparison

<table>
<thead>
<tr>
<th></th>
<th>New Design:</th>
<th>Original Design:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>PE High Density: 1.7E-5 kg PO₄e</td>
<td>PVC Rigid: 3.6E-5 kg PO₄e</td>
</tr>
</tbody>
</table>

### Material Financial Impact Comparison

<table>
<thead>
<tr>
<th></th>
<th>0.03 USD</th>
<th>0.04 USD</th>
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</thead>
<tbody>
<tr>
<td>Use</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>End Of Life</td>
<td>4.9E-6</td>
<td>6.6E-5</td>
</tr>
<tr>
<td>Transportation</td>
<td>5.3E-6</td>
<td>7.3E-5</td>
</tr>
</tbody>
</table>

### Manufacturing Financial Impact Comparison

<table>
<thead>
<tr>
<th></th>
<th>0.254</th>
<th>0.347</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>End Of Life</td>
<td>6.3E-3</td>
<td>8.6E-3</td>
</tr>
<tr>
<td>Transportation</td>
<td>0.017</td>
<td>0.023</td>
</tr>
</tbody>
</table>

### Use Financial Impact Comparison

<table>
<thead>
<tr>
<th></th>
<th>0.023</th>
<th>0.026</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>End Of Life</td>
<td>8.4E-3</td>
<td>0.012</td>
</tr>
<tr>
<td>Transportation</td>
<td>1.1E-3</td>
<td>1.6E-3</td>
</tr>
</tbody>
</table>

### End Of Life Financial Impact Comparison

<table>
<thead>
<tr>
<th></th>
<th>0.913</th>
<th>0.882</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>End Of Life</td>
<td>6.3E-3</td>
<td>8.6E-3</td>
</tr>
<tr>
<td>Transportation</td>
<td>0.017</td>
<td>0.023</td>
</tr>
</tbody>
</table>

### Transportation Financial Impact Comparison

<table>
<thead>
<tr>
<th></th>
<th>0.00</th>
<th>0.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>End Of Life</td>
<td>4.9E-6</td>
<td>6.6E-5</td>
</tr>
<tr>
<td>Transportation</td>
<td>5.3E-6</td>
<td>7.3E-5</td>
</tr>
</tbody>
</table>
The plunger with the sliding button, requires a material that is rigid enough in order not to break easily due to the forces that are being applied to the slider. The baseline material was set to HDPE, whereas PP slightly improved the environmental impact. The detailed results of the LCA are illustrated at the graphs below.
### Environmental Impact Comparison

#### Carbon Footprint - Comparison

<table>
<thead>
<tr>
<th>Total</th>
<th>PP Copolymer: 0.011 kg CO₂e</th>
<th>PE High Density: 0.013 kg CO₂e</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>New Design: Better 5.6E-3</th>
<th>Original Design: Baseline 5.5E-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>New Design: Better 3.0E-3</td>
<td>Original Design: Baseline 3.2E-3</td>
</tr>
<tr>
<td>Use</td>
<td>New Design: 0.00</td>
<td>Original Design: 0.00</td>
</tr>
<tr>
<td>End Of Life</td>
<td>New Design: Better 1.9E-3</td>
<td>Original Design: Baseline 2.0E-3</td>
</tr>
<tr>
<td>Transportation</td>
<td>New Design: Better 2.6E-4</td>
<td>Original Design: Baseline 2.7E-4</td>
</tr>
</tbody>
</table>

#### Total Energy Consumed - Comparison

<table>
<thead>
<tr>
<th>Total</th>
<th>PP Copolymer: 0.273 MJ</th>
<th>PE High Density: 0.281 MJ</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>New Design: Better 0.211</th>
<th>Original Design: Baseline 0.216</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>New Design: Better 0.057</td>
<td>Original Design: Baseline 0.060</td>
</tr>
<tr>
<td>Use</td>
<td>New Design: 0.00</td>
<td>Original Design: 0.00</td>
</tr>
<tr>
<td>End Of Life</td>
<td>New Design: Better 1.4E-3</td>
<td>Original Design: Baseline 1.5E-3</td>
</tr>
<tr>
<td>Transportation</td>
<td>New Design: Better 3.6E-3</td>
<td>Original Design: Baseline 4.0E-3</td>
</tr>
</tbody>
</table>

#### Air Acidification - Comparison

<table>
<thead>
<tr>
<th>Total</th>
<th>PP Copolymer: 3.4E-5 kg SO₂e</th>
<th>PE High Density: 3.6E-5 kg SO₂e</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>New Design: Better 1.2E-5</th>
<th>Original Design: Baseline 1.2E-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>New Design: Better 2.0E-5</td>
<td>Original Design: Baseline 2.1E-5</td>
</tr>
<tr>
<td>Use</td>
<td>New Design: 0.00</td>
<td>Original Design: 0.00</td>
</tr>
<tr>
<td>End Of Life</td>
<td>New Design: Better 1.1E-5</td>
<td>Original Design: Baseline 1.2E-5</td>
</tr>
<tr>
<td>Transportation</td>
<td>New Design: Better 1.2E-5</td>
<td>Original Design: Baseline 1.3E-5</td>
</tr>
</tbody>
</table>

#### Water Eutrophication - Comparison

<table>
<thead>
<tr>
<th>Total</th>
<th>PP Copolymer: 4.0E-6 kg PO₄⁻e</th>
<th>PE High Density: 5.9E-6 kg PO₄⁻e</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>New Design: Better 1.2E-5</th>
<th>Original Design: Baseline 1.1E-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>New Design: 7.2E-7</td>
<td>Original Design: 7.7E-7</td>
</tr>
<tr>
<td>Use</td>
<td>New Design: 0.00</td>
<td>Original Design: 0.00</td>
</tr>
<tr>
<td>End Of Life</td>
<td>New Design: 1.9E-5</td>
<td>Original Design: 2.0E-5</td>
</tr>
<tr>
<td>Transportation</td>
<td>New Design: Better 2.7E-7</td>
<td>Original Design: Baseline 2.9E-7</td>
</tr>
</tbody>
</table>

#### Material Financial Impact Comparison

<table>
<thead>
<tr>
<th>New Design</th>
<th>0.01 USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Design</td>
<td>0.01 USD</td>
</tr>
</tbody>
</table>
5. Conclusions

Despite the fact that Toothpaste Market is one of the most dynamic segments of the oral care market, little innovation has been occurred on the packaging of toothpaste, considering the fact that the market is still dominated by the tube, a packaging device that was initially launched in 1892.

Since traditional toothpaste tubes cause many functional and environmental problems, in the specific project has been made an effort to propose a new packaging design that is not only environmental friendly, since all the parts are detachable and from recyclable materials, that facilitate the process of separation and recycling and allows full export of the product from the package, but is also user- friendly, too. To enhance the environmental awareness, the device could also be reusable and the inside vessel containing the toothpaste, could be purchased separately in the market, as a replacement part.

As far as the methodology of design process is concerned we can conclude that every project has needs that are unique and factors such as the objective of the project, the available information and the provided accessibility and timing constraints which may affect the order and flow of the designing phases, while the need for evaluation, with the ultimate aim to filter information deemed necessary at each step, like the continuous feedback with the requirements.

The design proposals derived from this process, seems to achieve the objectives set on the design brief. However it is worth noting that the simultaneous satisfaction of all requirements is usually not feasible and constitutes a major challenge in the design process.

For the selection of the material, we can conclude that is a huge chapter in product design application, and despite the fact that there are materials that are more sustainable than others,
more considerations should be taken into account, in terms of financial impact, mechanical properties, optical properties, in order the design to give the best feeling to the product and find a better balance, while further research could be done to materials which allow full slipperiness of viscous liquids in order to solve the problem of residues.

For the production method used, many considerations should be taken into account, especially in the design of the molds, so as to eliminate potential problems which may arise.

Furthermore, the observation that more and more people have become conscientious about the environment and the products that chooses to use is very encouraging. On the designer aspect, we must not forget the social responsibility that has, and often the need for innovation and originality in terms of improving the comfort of everyday life can lead to waste of materials and destructive solutions for environment. The simplicity of the past might be an innovation of the future, since less is more.
6. Further Study

In order to confirm the applicability of the proposed toothpaste extraction mechanism from the container and for reasons of a more valid evaluation of the proposed ideas, in order to examine more accurately operational characteristics and the ergonomics of the handle, as well as technical characteristics pertaining to the method of production, it would be more appropriate, the creation of prototypes, initially using new technologies such as 3D Printing that could be used in a second phase, for the creation of molds during the injection molding process. In this way, the results would certainly be more reliable and objective as users would be those who would empirically provide feedback to the design process giving solutions to more detailed data.

Regarding the production method, certainly the analysis of the injection molding process, on a theoretical level could help in gathering information for the points which should be given more attention like geometrical constraints. This would be more comprehensive, by carrying out a simulation of the injection molding process with the aid of a software.

As mentioned in the first part of the research, an equally important factor, which plays an important role in consumer behavior and constitutes a significant selection criterion among many competitive products, is the cost. The economic assessment was not a primary objective of this thesis but it could be studied further as well it would help considerably in testing the viability of launching of a new innovative product onto the market, as well in predicting the factor of success.

As far as the selection of materials is concerned, another design criterion to be studied, could be the compatibility with the ingredients of the toothpaste, as we must not forget that the main role of packaging is to protect the product itself. An additional study, could be the research on materials that have functional properties too, like allowing full slipperiness of viscous liquids in order to solve the problem of residues.
It could also be performed a comparative assessment of sustainability, of the entire life cycle between conventional toothpaste tubes and the proposed project.

Finally, the need to create a methodological framework which takes into account the factor of sustainability from the very beginning remains underexplored.
References

Chapter 2


Chapter 3


Appendix

A. Types of Thermoplastics

Below there is a brief reference of the most common types of thermoplastics commercially available. (“Identifying Recyclable Resources”, 2017)

**Polyethylene Terephthalate (PET(E))**

The primary use of Polyethylene Terephthalate concerns the manufacturing of garments, in particular fibres for clothes, and is widely used in food containers and beverage packaging, pharmaceuticals and cosmetic packages. Their common element is that the production method which is injection moulding. The reason PET is so widespread, are the multiple benefits it offers, especially in the packaging sector. First of all, the low breakability is a great advantage combined with the fact that is pure and as a result comestibles that are provided in PET vessels retain their original taste, and permits the products to remain for a long time on shelves since it has excellent barrier properties. Its weight is very low and the ability to appear pellucid provides a sense of clearance. Additionally it sinks in water and provides an economic solution during shipping and handling and is acceptable from companies universally.

**High-Density Polyethylene (HDPE)**

Due to the fact that the density of HDPE is about 0.941 g/cm³, it is a material with great stiffness and strength properties. The intermolecular forces and tensile strength are sufficiently strong, making the HDPE solvent resistant solvents. Commonly encountered in containers for water or milk, cleaning products and personal cosmetics.
**Poly Vinyl Chloride (PVC)**

The key ingredient of PVC is chlorine and as a result during production it may emit hazardous dioxins. Instead of that, the fact that it is lubricant and chemical resistant plus the great strength and impact properties makes it suitable for wraps such as takeaway vessels, chemical dispensers, flexible bags, plumping pipes. Except from packaging other applications include kayak manufacturing, carpets, exterior trash bins, traffic cones and mailboxes.

**Low-Density Polyethylene (LDPE)**

The fact that intermolecular forces are weaker in LDPE than the HDPE, contributes to weakness in modulation of crystalline structure, making it more ductile material with reduced tensile strength. LDPE is a product of polymerization with varying density values between 0.910 and 0.940 g/cm3. Through the heat, it is easy to melt, while the chain structure, provides unique flow properties. Other additional features are durability, flexibility, resistance to acids and lubricants, and the excellent crystal clear optical attributes. It is usually found in stretch films, shrink wraps, bubble wraps, zip-lock bags, grocery bags, squeezable containers, milk carton coatings, trash bins, floor tiles, and outdoor furniture.

**Polypropylene (PP)**

Polypropylene, or else polypropene, is considered a multilateral thermoplastic material, since its properties are approaching greatly those of LDPE and HDPE. It has good translucency, it resists to chemicals, has great durability and fatigue strength and thus suitable for hinges, it is semi rigid and does not allow heat transfer and moisture permeation. Applications are found in pharmaceutical containers, single use containers, caps for bottles, cutlery and packaging for refrigerated products. It is a common material in automotive industry, household and outdoor tools, too.
Polystyrene (PS)

Polystyrene is also a product of polymerization, which before passing the injection molding process in order its geometry to be shaped, the Polystyrene resin is impregnated by a blowing agent and thereafter it is re expanded with hot steam and subjected to curing, while the process ends with drying ovens. There are two categories of products, rigid PS and Styrofoam (EPS). Some of the properties of Polystyrene are high stiffness, transparency, low weight, no heat transfer, and moisture resistance. Applications include, food packaging like meat trays, takeaway coffee cups, CD casing, single use plates, switches and toys.
B. Proposed Concepts Dimensions

SIDE VIEW

TOP VIEW

FRONT VIEW

Dimension units in cm

CONCEPT 1 - SAY CHEESE

Package 1 Assem
Dimension Units in cm

CONCEPT 2 - DENTAL FRESH

AssemFinal_closed_Lid

A4
Dimension units in cm

CONCEPT 4 - CRYSTALLINE

Final Case Assembly

A4

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