Packaging Design for Cheddar Cheese based on marketing, logistics & environmental criteria

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SCHOOL OF ECONOMICS, BUSINESS ADMINISTRATION & LEGAL STUDIES
A thesis submitted for the degree of Master of Science (MSc) in Strategic Product Design

December 2017
Thessaloniki – Greece
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December 2017
Thessaloniki - Greece
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Abstract

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

In previous decades, landfill was the recommended way of recycling and plastic was one of the common used materials for packaging purposes. Because of activities in food industry, it is observed an increase of greenhouse effect emissions and global warming, so there is an upcoming need to reduce these emissions by reducing packaging materials and packaging waste respectively.

In this study, it is settled as a goal a design for an eco-friendly package of Cheddar cheese based on marketing and logistics criteria too. There have been examined a lot of different marketing studies and surveys in order to understand consumer’s perception about eco-friendly issues and their purchase decisions. In this direction, there is an effort to design a thick, low-weighting and single layer principal package for Cheddar cheese by examining two different concepts for Cheddar cheese shape and its relevant principal package. Its material is a low-density poly ethylene film in which has been incorporated methyl chavicol (a natural ingredient of Basil as an inhibitor against microbiological threats). Also, there have been designed a suitable external package of biodegradable materials (Kraft Pulp, Wheat Straw) in order to protect the content against physical destruction and UV exposure. These materials have also been used in different combination for a recommended extra external package in order to be safely delivered through the distribution channels.

This dissertation was a challenge because I had to combine three different parameters in order to design an eco-friendly package, so I would like to thank my supervisor Dr. Charisios Achillas who was my counsellor because he settled the guidelines of the study and he advised me in each crucial stage. Also, I wish him to be in good health in order to continue his academic work and his important contribution in the academic society.

Keywords: Cheddar Cheese, New Package, Marketing, Environmental Impact, Logistics

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23/12/2017
Preface

Nowadays, health professionals suggest a diet which will combine nutritional and environmental criteria too (Whybrow & Macdiarmid, 2016) while this type of diet is also a fact in countries like Netherlands and Sweden (Health Council of the Netherlands, 2015; Livsmedelsverket, 2015). A healthy diet will be based on recommendations such as eat as much food as it is required for personal needs, reduce the consumption of highly processed and packaged food and promote fruits and vegetables (Garnett, 2014, Pearson et al, 2014, Van Dooren et al, 2014).

Consumers as individuals should adapt an eco-friendly behavior on their everyday routine and industries should enhance these efforts by adapting an eco-friendly model for food production processes and their packaging materials.

As far as an industry, it can apply immediately measures in order to minimize the environmental consequences which are also associated with direct environmental impact. These types of actions can be the prevention of usage of hazardous substances such as chemicals additives or chemicals through processes. Also, there are actions concerning energy limit through cooling or heating processes because it is also important to be achieved a chemical and microbiological sustainable product with the least energy consumption

Activities, which are related to indirect environmental impact concerning product waste, its packaging components and its distribution through the supply chain (Nilsson et al., 2011). In this context, a well-preserved product with extended shelf life and reduced food waste may represent a good innovative approach (Galanakis, 2012).

As far as packaging material, packaging waste and their environmental impact there are actions characterized as life cycle assessments (LCA). These changes in packaging stage will also contribute on economic field because it will prevent product losses (Vanderrost et al., 2014) which is translated into no waste of money.
Introduction

In 1980s, plastic was one of the most common materials for packaging purposes but there was not a clear view about its energy or material consumption, its solid waste and its emissions too (Sonneveld, 2000). It should be mentioned that there was a gap in legislation (94/62/EC) concerning life cycle aspects related to packaging and packaging waste because food waste is on a higher level associated with the environmental impact. Landfill was the recommended way of recycling, so industry’s matter was the protection of the content (product’s structure), its microbiological and chemical quality to satisfy consumer’s needs.

In recent decades, there is an interest for human activities in relationship with their environmental impact because of global warming and greenhouse effect issues.

Because of such activities in food production process, an increase of greenhouse effect emissions is observed, with their percentage being estimated at around 30% (Garnett, 2014). Furthermore, it is calculated that household waste percentage is deteriorated at around 20% (Molina et al., 2016) which means that a new eco-friendly package with the least possible packaging waste should be developed.

In this direction, there are a lot of new innovative applicable technologies in food products which achieve its microbiological and chemical sustainability with the minimization of food waste respectively. These types of recommended packages are based on studies for active and bioactive packages, edible coatings or films and incorporated anti-microbiological ingredients.

In this study, it is settled as a goal the construction of such a new package for Cheddar cheese. One of all these technologies will be combined with a recyclable external package in order to be delivered a well-performed, eco-friendly and low-cost package in the market. This package is supposed to be a motivation for industries and distribution channels so as to improve their packaging materials and reduce their waste while their competitiveness should be maintained stable respectively.

Firstly, the package should be acceptable from consumers as a part of the product which means that it is necessary to be analyzed consumer’s thoughts for these new types packages. Also, the package should be well-performed to gain ground against similar or relevant
products in the market (marketing goal). Furthermore, it should be checked which one of all these eco-friendly applicable technologies in Cheddar cheese is also the most efficient package against microorganisms or other chemical and physical threats (environmental goal). Finally, it should be a low-cost package with the least needed amount of energy consumption through its distribution to the supply chain (logistics goal).

This study contributes in food packaging research by designing an innovative principal, external and extra external package composed by different materials except from common used plastics and cartons. Also, it will be an interesting point of view for consumers because it will be designed based on their purchase decision and their perceptions about environmental friendliness and innovative applicable technologies in foods. Finally, it should be underlined that this package will promote Cheddar’s cheese chemical and microbiological sustainability and it will also be appealing, good manageable and eco-friendly too.
Literature Review

Marketing

Consumers demand to find labelled products with environmental characterization, but it does not correspond to their same food choices (Van Dam and Van Triip, 2013). On the other hand, FAO (2010) does not discriminate foods or food behaviors which are both eco-friendly and healthy too and in case of organic products, it is evident that consumers are driven to purchase by their feelings (Aertsens et al., 2009).

It is important to be analyzed what green packaging is and if consumers are determined to pay for such technologies applied in a food product (Hoek et al., 2017). In this direction, a detailed analysis of their perception is needed in order to deliver the right answers through marketing so as the expected final product to be acceptable and successful in the market.

Consumer’s Perception About Green Packaging and Food Waste Recycling

Most of consumers do not have a clear definition in their mind about what characterize a food as environmental friendly because the association of eco-friendliness is related to “organic” and “free-range” food product and less with recycling in their mind. (Hoek et al., 2017).

Based on a study which is conducted for the Australian market (Hoek et al., 2017), consumers define what eco-friendly behavior is and if this behavior is relevant to food package and waste.

In a short summary, the study differentiates them between medium to highly-aware and low-aware consumers about specific issues. Especially, highly-aware consumers believe that they should be a part of efforts related to environmental issues while low-aware consumers are just optimistic about their own behaviors.

 Australians seem to be aware of packaging issues related to highly processed foods, but some of them do not know about the processes which take place to have a food in their table. While they have negative thoughts about highly processed and packaged food which contain additives, their belief is that these types of products have a medium environmental impact because of less used packaging material.
Moreover, when they have been asked not to waste food, so as to be easily understood how relevant is food waste with a negative environmental impact in their mind. A lot of participants are in favor of not wasting their food even for financial or social reasons. While they are positive enough because it has a medium to high positive environmental impact, they do not know if it has an impact on their health. Especially, they are highly motivated, and they believe that a combination of actions should be taken in cooperation with supermarkets, industries and restaurants. The result of these actions will be a better distribution channel than the existed one with the least food and packaging waste respectively. They recommend as a strategy a larger package than the existed one as an effort to reduce their household waste which is translated into the least possible landfilled amount of packaging materials.

Finally, there is another study which supports that consumers are motivated to recycle because of their age (social parameter) and their political beliefs. Especially, most of them believe that water source recycling is more important than packaging recycling and landfill actions are supposed to have a negative environmental depict in their mind. Also, carton and glass packaged products cause the least environmental pollution (Kimberly et al., 2016).

**Consumer’s Purchase Decision**

Purchase decisions are relevant to taste and convenience which should remain steady as product characteristics even if the whole process of their production entirely changes. When a package combines information, convenience and aesthetics, customers are grateful and pleasant to pay for it.

These parameters may be driven consumer purchase decision, but it should be underlined that price also plays an important role in their decisions. Especially, a research showcases that consumers notice as a barrier product’s cost even if it is healthy and environmentally sustainable (Pearson et al., 2014). Also, consumers believe that product’s eco-friendliness is an extra and not a depict characteristic to pay for it (Aschemman-Witzel, 2015). Obviously, further information about product alternatives is required as an effort to convince consumers pay for it.
In case of similarity between products, it should not be underestimated that it can be more easily accepted a product in the market as an alternative one with a higher price even if there are closely relevant. Also, it is needed an approve which characterize it as a better alternative and its higher price will be more easily accepted, an example of such a fact is brown and white rice price (Felcher et al., 2001).

**Customer’s Perception About Innovative Applicable Packages in Foods**

High-pressure processing and pasteurization are some of the most common procedures which take place in order to be delivered a hygiene safe and qualitative food product in consumer’s table, but there are also studies concerning packaging materials which contribute on its delivery through the supply chain and maintain its microbiological and chemical sustainability.

These applicable packages in food products can be active and bioactive packages, edible coating or films and incorporated anti-microbiological components. All these packages and packaging materials seem to be innovative and functional too, but consumers do not have a clear definition in their mind about what exactly is their application because their need is an informative, easy to use and aesthetically desirable package (Williams et al., 2008).

Active package is a natural, recyclable and biodegradable type of package (Lopez et al., 2004), in which can be applicable anti-microbiological substances on food surface. Substances can be incorporated with two different techniques such as dipping or spraying. Its purpose is microorganism’s inhibition even by absorbing or releasing these substances with their percentage is rated at 0.5-1%, its effectiveness is an important fact during storage and transport (Appendini et al., 2002). The only difference between bioactive and active package is that bioactive package contains ingredients which help positively consumer’s health.

Edible coating and film can be a part of an active package and it can contribute even by preventing microorganism’s growth or oxygen’s reduction. A conducted survey showcases that 77.6% high-level educated consumers are not aware of active package definition (O’Callaghan and Kerry, 2016).

Nanotechnological material is described as a functional material whose size is between 1 and 100 nm (Royal Society and Royal Academy of Engineering, 2004). Setting as a goal the
appearance of novel foods and food packages, nanotechnological material can act as a mechanism against microorganism’s growth or it can be barrier against a possible mechanical decomposition of food (Chowdry, 2010). Furthermore, nanotechnological material can play the role of transfer for specific food ingredients (Weiss et al., 2006).

Most of consumers seem to ignore the existence of nanotechnology because it is an unknown field (Besly, 2010) and lots of Americans believe that it can be a less risky technique with the most efficient results (Curall et al., 2006). On the other hand, Europeans are more pessimistic of its functionality (Qaskell et al., 2004).

**Consumer Perception for Cheese Differentiations**

There are a lot of different varieties of cheeses which are preferable due to their traditional character and any modifications or new smart packages are not well-welcomed when the content is spoiled and their taste change (Trenbult et al., 2005). A study (Drake et al., 2009) shows that American sharp cheddar cheese consumers sometimes purchase because of its description as sharp flavor or even by its brand name and label of region.

There is another conducted survey for multinational respondents in an Irish University as an effort to understand consumer thoughts about new applicable technologies on cheese and it can be referred as representative survey for Cheddar cheese because most of respondents consume more frequently Cheddar cheese.

The survey concludes that consumers store hard cheeses for weeks and they are blissfully satisfied by cheese shelf life. A possible explanation of such an aspect is that hard cheeses have the least moisture among others and their consumption is highly enough. Also, their preference can be a result of its long-shelf life. On the other hand, they are dissatisfied when they have to buy a sliced cheese parts or portion of a cheese and their negative feelings are evident when the expiration date differentiates from the expected indicated one.

As far as changes which can be occurred for cheeses and their packaging materials, middle-age and elders do not prefer any type of different and unknown technological improvement in their package. Especially, many of them are against chemical additives but in case of a natural additive which means that it comes from a natural ingredient they will give a try to consume it.
Finally, they believe that storage instructions, reduction in packages and changed portion sizes will contribute on differentiate their opinion for new package because they replace product package with a homemade one in order to preserve it.

**Consumer’s Manipulation Techniques Related to Eco-Friendly Behavior**

Based on previous statistics concerning greenhouse effect emissions and global warming issues related to food production and consumer’s consumption, it is needed a strategy to manipulate and change consumer’s behavior so as to be more environmental friendly following a healthy and sustainable diet.

Most of consumers do not buy a product because they have been motivated by their environmental consciousness even if consumers are aware of environmental issues, it is needed a comparison between similar foods. When consumers are going to buy a product almost every time they are influenced by pride or quilt (Antonetti et al., 2014).

In case of food waste, consumers are also driven by their feelings and basically by their negative esteems such as quilt or blame from next generations. Especially, it is observed that creating these feelings, it can be an approach for food waste reduction (Graham-Rowe et al., 2014).

**Environmental**

In previous decades, industry’s matter was not the environmental consequences related to production process and package because the legislation was focused on recycling by landfill and industries create smaller packages than the existed one so as to reduce their waste.

The packaging environmental consequences are also divided into direct and indirect. The direct environmental impact of a package concerns its packaging life cycle and the indirect is relevant to product waste and life cycle assessments (LCA) which is a common used definition by companies for packaging materials and waste (Ferreira et al., 2015; Grant et al., 2015; Rossi et al., 2015).
When a designer sets as a goal such a new product package except from its communication with consumers (marketing goal), package’s informative role is more closely relevant to its functionality because consumers need to know its expiration date, its logo or label and other characteristics. Each of these changes can be applicable in a package when product’s consumption is safe, and it should be searched in depth which changes can be occurred for an eco-friendly package.

Food waste, packaging materials and packaging waste reduction and improvements in printing are some of these changes but there are also a lot of technical barriers which should not be underestimated for a food. These technical frames are its non-physical destruction or fragility, its microbiological and chemical sustainability.

**Eco- Friendly Package**

The adjustments on packaging materials concern its thickness which means that its volume and weight should be as low as it is required for its hygiene safety. The purpose behind a thick low-weighting package is a package with the least energy consumption through its production. When a package contains a lot of different materials it is also difficult to be recycled. These types of packages or part of packages can be single layer modified atmosphere package, hydrophobic interior surface, edible coatings or films and incorporated natural ingredients

As far as food waste, it should be mentioned that a package whose dimensional fitting is perfect, and it is not large enough is clear that it can be a good solution for food waste reduction because consumers can handle it more easily (Molina et al., 2016).
Cheddar Cheese

Cheddar cheese is one of the most worldwide known and eaten cheese because of its desirable aromas related to lactic and amino acids. It is a type of hard cheese and its related dry-salted cheese varieties are produced by pasteurized standardized cow’s milk. The only Protected Designation of Origin (PDO) Cheddar Cheese is the one which is produced in the region of Somerset in England. Cheddar’s maturing period lasts 12 months and its preparation includes 15 stages with the most characteristic “cheddaring” process (Ramesh et al., 2011). Moreover, there is a study which supports that a cheese like Cheddar can be used as transfer of probiotic bacteria strains to consumers (Phillips et al., 2006).

It should be underlined that there are limits related to possible quality issues which should be avoided from its possible new eco-friendly package for Cheddar cheese.

Cheddar Cheese-Quality Issues

In this long term-process, the initial mesophilic strains are *Lactococcus lactis* but there are also a lot of different strains which appear and contribute for the final desirable product. The different quality issues concern Cheddar’s appearance, body and texture. Some of them can be occurred on preparation stages such as cooking, cheddaring and ripening process while others are related to packaging stage.

Cooking is a preparation stage when pH drops to 6.2. The second stage is related to product’s name, it is called “cheddaring” process. In this stage, the whey should be removed to 70% or 50% and the pH should be further decreased to 5.3 respectively. The blocks of Cheddar are pressed in drums and vacuum packed to get ripened. Salted blocks of Cheddar are then ripened at 4-8°C for a period between 3 and 48 months depending on the expected desirable aromas and its hygiene safety. Also, the ripening period is closely related to flavor, especially when the ripening period is longer the flavor is going to be sharper. Based on ingredient analysis, the expected final Cheddar cheese is supposed to have 37.5% moisture, 23.8% protein, 32.5% fat and 1.7% salt (Guinne, 2003).

The bacteria which grow through the process, can be strains of *Coliforms*, *Clostridia*, *Propionibacterium* and *Escherichia coli*. Bacteria, which are involved on preparation stages, mainly are relevant with Cheddar’s appearance while some of them concern body and texture
faults. *Coliforms, Clostridia* and *Propionibacterium* cause holes because of their gas production which sometimes is accompanied by fruity or sweet nut-like flavor.

In preservation stage, *Listeria monocytogenes* is bacterium which survive at a refrigerator and can appear in Cheddar cheese. *Listeria monocytogenes* is responsible for a food born illness called listeriosis which sometimes can lead to consumer’s death, so it cannot be underestimated its appearance, but except from this bacterium the appearance of yeasts and molds is also important in Cheddar cheese.

Yeasts are responsible for spongy body and mold’s growth is observed on cheeses’ surface. Specifically, there are a lot of different species of molds which can be observed on cheese surface such as *Penicillium* (Pitt, 1988), *Fusarium* (Nelson et al., 1983) and other such as *Aspergillus, Phoma* and *Cladosporium*.

**The Role of Package**

Although a package is known for marketing purpose, it can underestimate its functional role. Especially, Cheddar cheese package should be well preserved through its distribution from the supply chain to consumer’s table, which means that a qualitative and hygiene safe Cheddar package is needed.

First of all, the package should promote Cheddar’s sustainability related to its moisture. Secondly, it is needed prevention against UV light exposure. Moreover, packaging prevents mold’s growth on cheese surface.

There are cases when portions or the entire surface of cheese are getting faded because of its moisture unsustainability as a result consumer are not willing to pay for such a product. As far as UV exposure, it is important to be avoided because when the cheese is being exposed to UV light calcium lactate is getting crystallized and it an undesirable sense of tasting. Mold’s growth can be inhibited by a vacuum package which prevent cheese exposure to oxygen-a main parameter for mold growth. *Listeria monocytogenes* is a bacterium which survives at 1 to 5°C and because of its importance it is needed a well-standardized preservation temperature because it can survive for more than a year to low-moisture food products (Ryser,1987).
In these days and age, the type of package which is applied on Cheddar cheese is called modified atmosphere package (MAP). This type of a packaging is consisted of multi-layer of different or same materials in order to achieve the desirable preservation environment. The recommended air composition of Cheddar’s MAP is 20-80% carbon dioxide with 0.5% or less oxygen because it can inhibit mold’s growth (Taniwaki et al., 2001). A research shows that cheddar cheese storage for 16 weeks at a low-density polythene (LDPE) package has a great impact against molds. Also, a package composition of 73% carbon dioxide and 27% nitrogen with oxygen scavengers is supposed to have the most effective microbiological results on Cheddar cheese (Oygi et al., 2007).

Applicable Packaging Techniques in Cheddar Cheese

There are a lot of different applicable techniques which extend Cheddar’s shelf life, promote its hygiene safety and contribute to the appearance of new packages respectively.

Based on a study (Suppakul et al., 2008), two components of scientifically recognized Ocimum basilicum L. (Basil) have been used to inhibit microbiological growth of Escherichia coli and Listeria innocua (bacterium with similar DNA to Listeria monocytogenes except from its pathogenicity). Packaging films contain 0.34 g of linalool or methyl chavicol in a low-density polyethylene package. The study showcases that both components positively contribute on microorganisms decrease with the total aerobic bacteria are decreased after 15 and 9 days respectively. Also, molds do not appear on cheese’s surface for more than 2 months. As far as Escherichia coli, methyl chavicol as additive continuously reduce its population for a period of 35 days at 4 °C, at the same temperature Listeria innocua population is being decreased for 35 days. The results at 12 °C are also positive enough due to rapid diffusion of components on Cheddar surface. Also, it is important that the two components do not change taste or any other sensory characteristics which means that it can be easily acceptable for consumers.

Anionic peptides are some anti-microbiological peptides come up from milk proteins and are used as anti-listeria factors. The whole preparation stages of Cheddar cheese are differentiated from the traditional recipe. Especially, in the study fresh cheddar is stored at -18 °C in simple plastic bags. The purpose of this action is a limited starter- culture. Incorporating Listeria monocytogenes, it ends up a storage period of 7 days at 30 °C and 28
days in a storage temperature of 4 °C. When Cheddar contains a low quantity of salt with salt/moisture at around 1.75 and anionic peptides around 20 mg/g respectively. Listeria monocytogenes reduction is observed for a storage period of 7 days at 30 °C, but it also observed when 10 mg/g anionic peptides are used at 4 °C temperature because *Listeria monocytogenes* reduces efficiently after 19 days.

A relevant study (Lynch et al., 2014) is conducted for anti-fungal purpose as an effort to expand Cheddar’s shelf life. Especially, *Lactobacillus amylovorus* strain is added as natural preservative through Cheddar production process. The results are positive because it adjusts mold’s appearance, maintain its biochemical characteristics same and expand its shelf-life for 2 days.

Also, in a comparative study related to bio preservatives and their effect in a storage period of 4 weeks at 16 °C (Ulpathakumbura et al., 2016). A bacteriocin produced by *Lactococcus* strains called nisin seems to have a great impact when it is used through Cheddar production process. Analytically, nisin does not influence sensory characteristics such as flavor and taste while it is incorporated in early stages of process before draining.

Another study (Limjaroen et al., 2005). showcases that 1.5 g of sorbic acid applicable on polyvinylidene chloride reduce *Listeria monocytogenes* population in a storage period of 35 days at 4 °C.

As far as crystallization effect which is also an important issue for Cheddar cheese, but it can be prevented when Cheddar cheese is close to its package (Rajbhandari et al., 2014)

**Logistics**

It is estimated that the relevant percentage of carbon emissions by energy usage through supply chain process is close to 80 and 90%, so it is needed a green supply chain which protects natural resources (Vackon and Klassen, 2006).

A recommended new model of “green” distribution channel sometimes seems to be impossible because supply chain contains a lot of different distribution channels and not as much as needed information. Furthermore, it may affect positively energy consumption but
simultaneously it can be a high-cost process in short-term, so all these changes should be counted because a company should maintain its competitiveness (Kleindorfer et al., 2015).

These types of life cycle assessment actions related to supply chain can be the reduction of cooling or heating needs through transport or storage, but also it can be actions related to product package even if there are small units or big one such as boxes, pallets and containers.

**Packaging Waste Prevention**

While life cycle assessment actions related to supply chain and product package will be efficient, it is also important the prevention of packaging or food waste. It should not be underestimated that EU solid waste percentage is estimated at around 15-20% (OECD, 2011:131) and the equivalent percentage in U.S., Australia and Canada is deteriorated at 30-35% per year (EPA, 2013; OECD 2013a). Their causes are relevant to consumer way of life (income, lifestyle) or consumption patterns such as small packages. Their limitation is important, and measures should be focused in design, production or usage stage (Tencani et al., 2016).

**Recommended Biodegradable External Packages**

Packaging system includes 3 phases: the protection of content, the protection of its package and an extra needed package for product’s distribution through the supply chain (Palsson and Hellstrom, 2016), so these changes will be occurred on units or on boxes, pallets and container. These packages should be limited in volume or in weight, but it also depends on product’s requirements.

As far as the protection of package and its extra needed package, consumers view positively a biodegradable package (Bidlingmaier et al., 2003) and there is a study which supports that biodegradable wet food package and food waste can contribute to a qualitative composting (Razza and Innocenti, 2012).
On the other hand, the whole process of a biodegradable material includes different stages. The biodegradable pulp should be shaped in a mould and it can be used for foods in case of Kraft pulp incorporation (ISO 2001).

![Diagram of the whole mould pulp production process](image)

Figure 1: Stages of the whole mould pulp production (Huo et al., 2009).

Generally, based on the study (Hu and Ma, 2004) manufacturing stage is responsible for 90% of the total environmental impact and the latter one study (Huo et al., 2009) refers that the manufacturing cost depends on the type of fuels which are used from packaging manufacture. Drying stage is the costliest stage of its general production (1/3 or general cost in case of burning diesel fuels) and the different type of fuels can reduce its cost effectively.

In another study (Curling et al., 2017), a biodegradable package box based on wheat straw and Kraft pulp is examined for its biodegradability and its density characteristics, as a result it come up positive ambitious enough alternative even the package is manufactured by 80/20 or 60/40 wheat straw/ Kraft pulp package. The density of box is bigger than an expanded polystyrene based box, so it can be useful in transportation. Also, the wheat straw– Kraft pulp system seems to be degradable after 4 weeks. The only disadvantage of such a system is that it cannot be easily bended, but a possible solution can be a thinner layer than the existed one (2.67 for 60/40 wheat/ Kraft pulp and 4.54 for 80/20 wheat/ Kraft pulp respectively.)

Also, another optimistic view is the usage of PLA and TPS as packaging materials in large scale for food packaging purposes because these materials will be available in future and it is recommended an anaerobic digestion (Rossi et al., 2015).
Packaging Design

Packaging design is an important part of a product except from its technical sustainability, a package act as an immediate way of communication between companies and consumers without misunderstandings. Also, it delivers information in the best possible way respecting legislation and it can attract consumers (Creusen and Schoormans, 2005). Brands can be easily recognizable by their logo or typeface and sometimes purchase decisions are driven by unconscious associations with a well-performed package.

Cross-modal Associations with Product Shape, Package Shape, Color and Graphics

Cross-modal association is a phycological parameter and it is a way that human brain corresponds specific physical or aesthetical characteristics of a product to specific senses. As far as food, its main goal is a great taste and it is associated with tongue because consumers can taste bitterness, sweetness and saltness of a food (Spence et al. 2015) but except from tongue the shape or the thickness of a product or even of its package is an indicated sign of its saltness, bitterness and sweetness.

It should be underlined that these associations vary and depend on population’s culture. For example, Westerns believe that rounded shapes are relevant to chocolate sweetness while residents of Namibia and a tribe of Kaokoland relate chocolate roundness with its bitterness (Bremner et al. 2013). Another example showcases that a thin shaped beer is a sign of its bitterness (Deroy and Valentin, 2011).

As far as package, its shape, color or even its graphics can also be part of these associations. Especially, package shape is linked in the same way with the product shape in consumer’s mind (Velasco et al., 2014) which means that a rounded package is related to sweetness and an angular package is linked to bitterness, sourness, saltness (Velasco et al., 2015). Also, the same fact is observed with typeface and brand shape which are estimated as a part of a package.

Graphic designs are a more complex part of package because it is a combination of a round or angular shape with upward or downward orientation or even by its positioning in package.
surface. Especially, an angular logo is associated with buildings in consumer’s mind (Fang and Mowen, 2005). A downward design with angular seems to be unlike in consumer’s mind (Larson et al., 2009).

All these observations are also in agreement with a survey conducted for University of Leeds (Westerman et al., 2013) when the participants have been asked if they are going to pay or if the product is appealing with a nice taste by its different shape. Also, the survey showcases that rounded graphics on the right side of product are more practical and more appealing, it can be explained by the interaction between human brain and vision.

**Gap Analysis**

While there is a research in depth concerning environmental, marketing and logistics parameters and how the package, its logo and graphic designs should look like based on consumer’s perceptions. There are also observed gaps in research concerning industries and distribution channels which will contribute on the designing of such a new package.

These gaps concern industry’s ability to apply these new technologies through their production process. For example, there is not information about the appliance of incorporated anionic peptides or Lactobacillus amylovorus strain in a large scale of an industry because these anionic peptides and strains can be a hopeful solution in order to design a new eco-friendly package. Also, it is not known if these applicable technologies are also an affordable solution for industry’s Cheddar cheese production process.

As far as the operations through the distribution channels, it is not clear which stages should be developed or removed in order to develop a “green” supply chain which as a fact will reduce the total cost of the final product respectively.
Methodology

Based on statistics from US Department of Agriculture, it is estimated that more than 1.36 thousand tons of Cheddar cheese are produced each year in U.S. Moreover, and it should be mentioned that its production remains steady year by year from 2004 to 2015. In a relevant perspective view, the total amount of produced cheese in U.S. is between 4.4 and 5.43 million tons each year (US Department of Agriculture, Economic Research Service, Statista 2017).

These representative statistics showcase that creating a new package for such a product it can be a hopeful step to eliminate the negative environmental impact in food industry. Also, Americans are not afraid of new technologies applied in foods with nanotechnology being identified as the less risky technique with the most efficient results in their mind (Curall et al., 2006).

As far as environmental criteria, the package should be a single layer package because it can be easily recyclable. A low-density polythene (LDPE) package can be applicable for Cheddar cheese (Oygi et al., 2007). Natural ingredients are preferable against other applicable technologies in foods and methyl chavicol in a low-density polyethylene package can inhibit the microbiological growth of *Escherichia coli* and *Listeria innocua* (bacterium with similar DNA to *Listeria monocytogenes* except from its pathogeny) (Suppakul et al., 2008). Also, methyl chavicol decreases the total aerobic bacteria after 9 days and molds don’t appear on cheese’s surface for more than 2 months. As an additive, methyl chavicol continuously reduce *Escherichia coli* and *Listeria innocua* population for a period of 35 days at 4 °C with the same positive results at 12 °C.

The incorporation of methyl chavicol in a low-density polyethylene package can also contribute on its distribution through the supply chain since there is no need for specific temperature for cooling needs. This action will minimize the energy consumption through product’s distribution to the supply chain and it can be a step for a “green” supply chain. Additionally, based on the logistics criteria, a biodegradable external package (Curling et al., 2017) of wheat straw and Kraft pulp can protect its package against UV light and its physical destruction through its distribution to the supply chain.
Moreover, the study conducted by Drake et al. (2009) can be a small representative view of U.S. market because it is conducted in 3 different regions (University of Illinois (UI), Washington University (WSU) and North Carolina State University (NCSU)) and it can also be a marketing approach.

Because of this study, there are some upcoming conclusions, which are briefly presented below:

- The description of sharp flavor or even the brand name and the label of region are driven their purchase decision.
- Cheddar cheese is commonly consumed on snacks while UI and WSU respondents consume it on sandwich, NSCU consume it on salads, soup or they just bake it.
- Consumers prefer its block forming package.

In this direction, based on another study (Palsson and Hellstrom, 2016), it is important to make measurements for:

- The dimensional fitting of a low-density polythene package(LDPE) on Cheddar cheese block surface (protection of content).
- The dimensional fitting of the external Cheddar cheese package (protection of its package).
- The recommended dimensions of the extra needed package for product’s distribution through the supply chain.

The limitation of this approach is the size of Cheddar cheese blocks. Their size is based on the conducted study (Suppakul et al., 2008) for methyl-chavicol because the inhibition period is immediately related with methyl-chavicol diffusion on Cheddar cheese surface and its expiration date too. Also, the usage of extra sensors in the external extra package is expected to increase its package total cost, which is a disadvantage for consumer’s purchase decision.
**Data analysis and Discussion**

Based on the study (Suppakul et al., 2008), the literature review showcases that a package whose dimensional fitting should be perfect, can be constructed by a low-density poly ethylene and a small percentage of ethylene vinyl acetate (EVA) in order to remain chemical, microbiological and sensory stable Cheddar cheese. In this study, it is also underlined that the package is activated even if its thickness is between 45 and 50 micrometers and the tightly enclosed Cheddar cheese dimensions are \(3 \text{ cm} \times 3 \text{ cm} \times 2 \text{ cm}\), weighting 20 g.

In this direction, the shape of principal package is the most important step because the other two packages (extra and extra external) will be designed based on its dimensions. There have been examined two conceptual designs concerning 18 blocks of Cheddar cheese in order to find the suitable one.

It should be explained that the number selection (18) is not deliberate and it is based on Cheddar cheese consumption which varies among population. Especially, it is based in an extreme case scenario that there is only one consumer who eats only 10 g (half block) of Cheddar cheese on his/her every day routine, there will be needed 36 days for its complete consumption and the product will be safe because its relevant expiration date is expected to be at 35 days when it closed and well preserved.

Because of its tightly enclosure for testing period, its expiration date is a limit because it will be more easily spoilages when Cheddar cheese will not be tightly enclosed as the study settled for the testing period. Setting as a goal the extension of its expiration date while eco-friendliness is the principal goal of the project, it is recommended a re-closing ability of the low-density poly ethylene package in order to eliminate at the best possible way its spoilage and its unsustainability too.

The sketches of Cheddar cheese top view and its package have been designed on Rhinoceros 3D Aided Computer Program and Adobe Illustrator CC 2017 respectively.

The first design, which concern an octagon shaped Cheddar cheese with its blocks \(3 \text{ cm} \times 2 \text{ cm}\) weighting at around 380 g.
Figure 2: Top View of Octagon Shaped Cheddar Cheese
Table 1: Dimensions of each Cheddar cheese block

<table>
<thead>
<tr>
<th>Block</th>
<th>Length (cm)</th>
<th>Width (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-8</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>9-16</td>
<td>2.38</td>
<td>3</td>
</tr>
<tr>
<td>17-18</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>20-21</td>
<td>2.87</td>
<td>3</td>
</tr>
</tbody>
</table>

For its complete tight enclosure of lateral sides, it is required 109.92 cm of film with a dimensional fitting of 2 cm height and it does not seem to be an optimistic plan.

Figure 3: 3D Model of Cheddar Cheese Package
For the second alternative there are settled the same parameters in order to make a comparison between them, so it is designed a rectangular package for 18 blocks of Cheddar cheese with their estimated weight at around 320 g. The dimensions of package’s frames are 27 cm × 6cm × 2 cm (height).

Figure 5: Top View of Rectangular Shaped Cheddar Cheese
It is observed that for the complete tight enclosure of lateral sides is required 66 cm of film with dimension fitting of 2 cm height. This fact enhances that the second alternative does not need as much as packaging material as the first one as a result its packaging weighting will be lower too. Concluding, the second concept seems to be more efficient against the first one and eco-friendlier too.

Moreover, setting as a principal package the second rectangular package, the external package should contribute on its non-physical destruction and protection against UV light exposure. Wheat straw and Kraft pulp can be a recommended combination of materials because of their biodegradability and appliance in foods (Curling et al., 2017).
When the percentage of wheat straw- Kraft pulp is 80 and 20 respectively, the package is difficult to be bended and it is a disadvantage for its enclosure. On the other hand, when wheat straw and Kraft pulp percentage is 60 and 40 respectively, it seems that the package is more fragile which is also a disadvantage because the product will be physically destructed. Concluding, their percentage should be between 80/20 and 60/40, because in this case the package will be more easily bended and not easily destructed.

Also, the external package should inform consumers about its content, so based on 2000/13/EC of the European Parliament related to labelling of food, the external package should include information about:

- Product’s name
- List of ingredients
- Quantity of certain ingredients
- Date of minimum durability or ‘use by’ date in the case of foodstuffs which are highly perishable from the microbiological perspective view
- Special storage conditions or conditions of use
- Business name and address of the manufacturer, packager, or seller

Also, based on 90/496/EEC, it is important to be presented the nutrition labelling such as energy value, protein, fat, fibre, carbohydrate, sodium and minerals.

As far as its graphics and shape, it should also be appealing (Westerman et al., 2013) which means that its graphics should be rounded on the right side with an upward logo (Larson et al., 2009) and the package shape should be angular in order to provoke its sharpness (non-sweetness) (Velasco et al. 2015).

Based on these studies, it is designed a box which looks like the presented mockup of the below picture. Also, it is presented a pattern with the required dimensions in order to be constructed a box like this for Cheddar cheese.
Figure 7: Mockup of Cheddar cheese package (https://zippypixels.com)

Figure 8: Mockup of Internal View of Cheddar cheese package (https://zippypixels.com)
Completing the designs of principal and external package of Cheddar cheese, it is also important a managerial insight of its acceptance from consumers, because even if consumers believe that a large package will contribute on the reduction of their household waste (Hoek et al., 2017), and another conducted survey (O’Callaghan and Kerry, 2016) showcases that consumers are dissatisfied when they have to buy a sliced cheese part or portion of a cheese.
Consumers like Americans taste a sharp flavor cheese and its block forming is the most common shape (Drake et al., 2009), it does not mean that this package will be easily accepted only by its shape and size. There will be needed an extended survey for a large part of population in order to have a representative feedback of their perceptions. Also, it is important to be conducted conferences and TV spots based on endorsements such as scientists and environmental conscious famous person in order to motivate consumers for the usage of such a different packaged Cheddar cheese.

Designing an external extra package, it is important for product’s distribution through the supply but there are also two factors which concern the extra external package. The first one concern industries, because a non-well designed external package will contribute on product’s well distribution through the supply chain and there will not be a spoiled product which should return, which means an extra cost for them. On the other hand, consumers do not want to pay extra money for a product because of its distribution, so temperature’s sensor are being rejected, so the only option an extra external package for limited Cheddar cheese package in order to eliminate the possible faults through its distribution and in case of spoilage, the economic cost will be minimized.

Wheat straw and Kraft pulp can be used as a combination of materials because of their appliance in foods and their biodegradability too. In this case, their percentage (wheat straw and Kraft pulp) should be 80 and 20 respectively because it should be constructed a high-density package. This fact will enhance the distribution of a great amount of Cheddar cheese without damages on each delivered final product.

The design concerns 18 boxes of Cheddar cheese, weighting at around 57.6 kg. The package will be stitched up in two of its later sides in order to remain stable.
Also, it should be underlined that it is recommended as a cheap option, the expiration date and serial number of its production to be scratched and inked in later sides and upper part of the package.
In this stage, it is recommended a observation in distribution channels in order to be understood if the extra external package is ergonomic and good manageable through the distribution channels.

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Serial Number</th>
<th>Month/Year</th>
<th>Serial Number</th>
<th>Month/Year</th>
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Figure 11: Position of scratched and inked Serial Number and Expiration Date of Cheddar cheese package
Conclusions

The purpose behind this study is a recommended design for an eco-friendly package of Cheddar cheese based on marketing and logistics criteria too. In this direction, it is important to be constructed a thick, low-weighting and single layer package which can be easily recyclable with the least energy consumption for its distribution through the supply chain.

The principal package which protect the content of Cheddar cheese can be characterized as eco-friendly because it is a single layer package constructed by low -density poly ethylene. Also, package’s thickness (45-50micrometers) enhances its eco-friendliness because it minimizes at the best possible way the volume of the package. The disadvantage of the package is a small percentage of a copolymer which has been used as a material in order to be easily incorporated methyl chavicol. This incorporation enhances product’s chemical and microbiological sustainability, but because of the extra added copolymer the package can be characterized as “not eco-friendly” as it is presented.

As far as the extra package, it is an example of applicable biodegradable materials in foods. In that case, product’s shape can be discriminated as angular, but it is not a clear angular such as triangle, so the graphics should prevail its sharp taste. Also, it is important that there is not unexploited space for its distribution which means that there is an elimination in energy consumption concerning fuels which will be used for its distribution.

Finally, the external extra package is also an eco-friendly because of its materials which offer high density (an important factor for distribution channel). The disadvantage of this package is that it cannot inform distributors about the content’s sustainability except from the expiration dates which are display scratched and inked in the lateral sides and upper side of the package.

The limitation of the project is the purchase decision of consumers, because even if consumers are determined to pay for new technologies applicable in foods, they are not determined to pay a lot of money for a product, so the burdens of the project are concentrated in the eco-friendliness of packaging materials, which have been used for the construction of principal, extra and external extra package of the product.
Because of consumer’s dissatisfaction for extra payment in order to have a product, it is indicated an extra research in the field of supply chain and packaging materials. It is evident that there is not a clear view of distribution channels in food industry, so researchers should focus in supply chain’s operations, which will contribute on the minimization of energy consumption through the distribution. A fact, which will also minimize product’s total cost, so any type of sensors will be used in order to receive a sustainable product. Also, it will contribute on the increase of its competitiveness against similar products.

Finally, it is important the development of a new packaging material alternative which will not require as an additive the copolymer EVA. This fact will enhance package’s eco-friendliness and it will also minimize its product’s cost.
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